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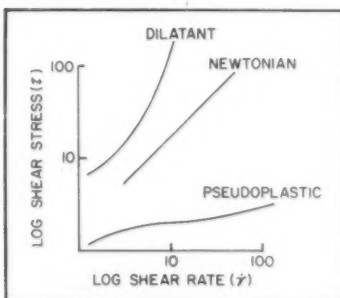
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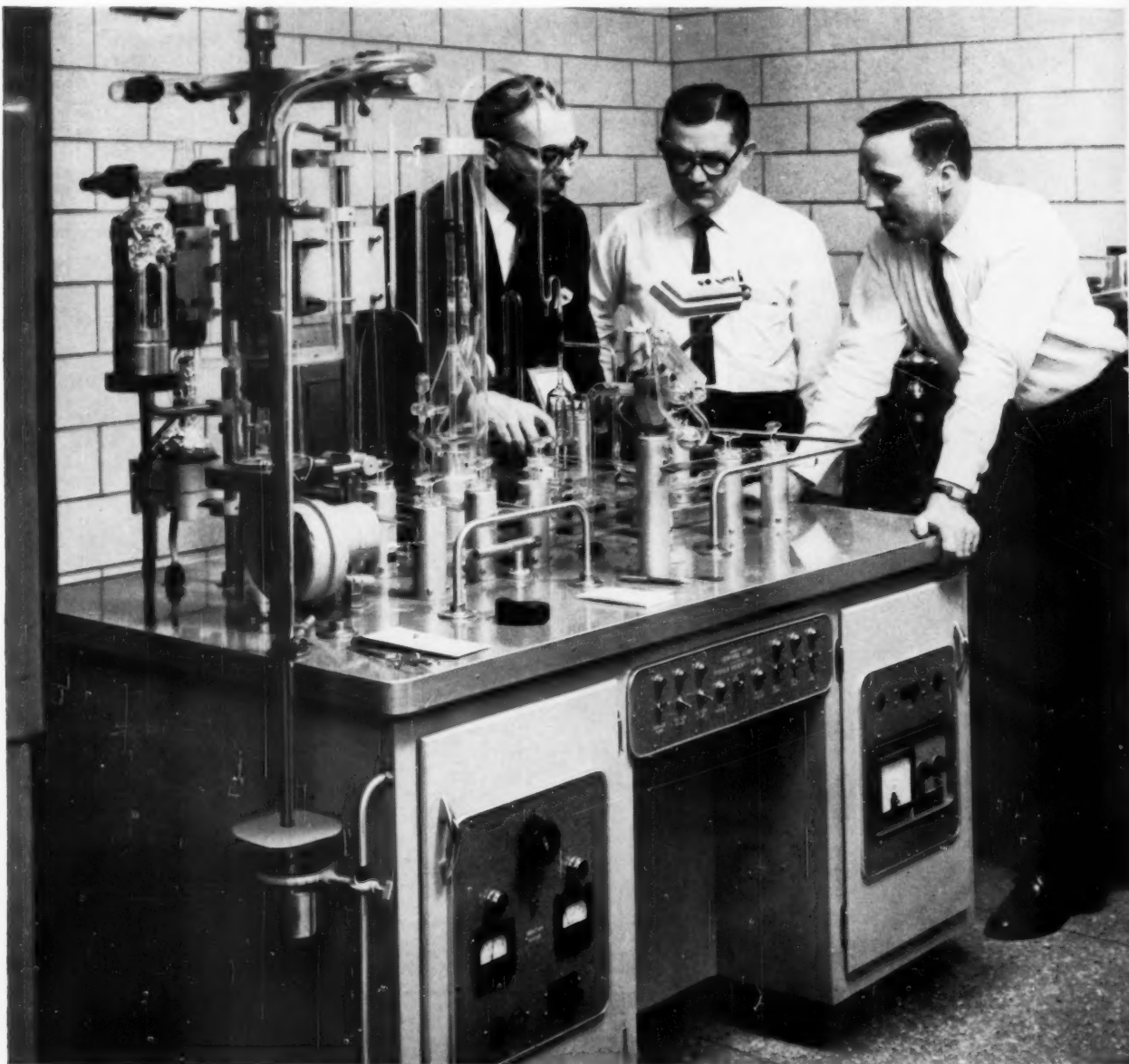
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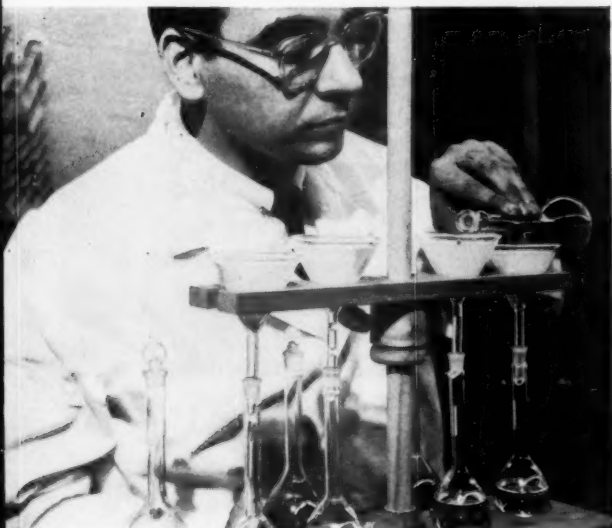
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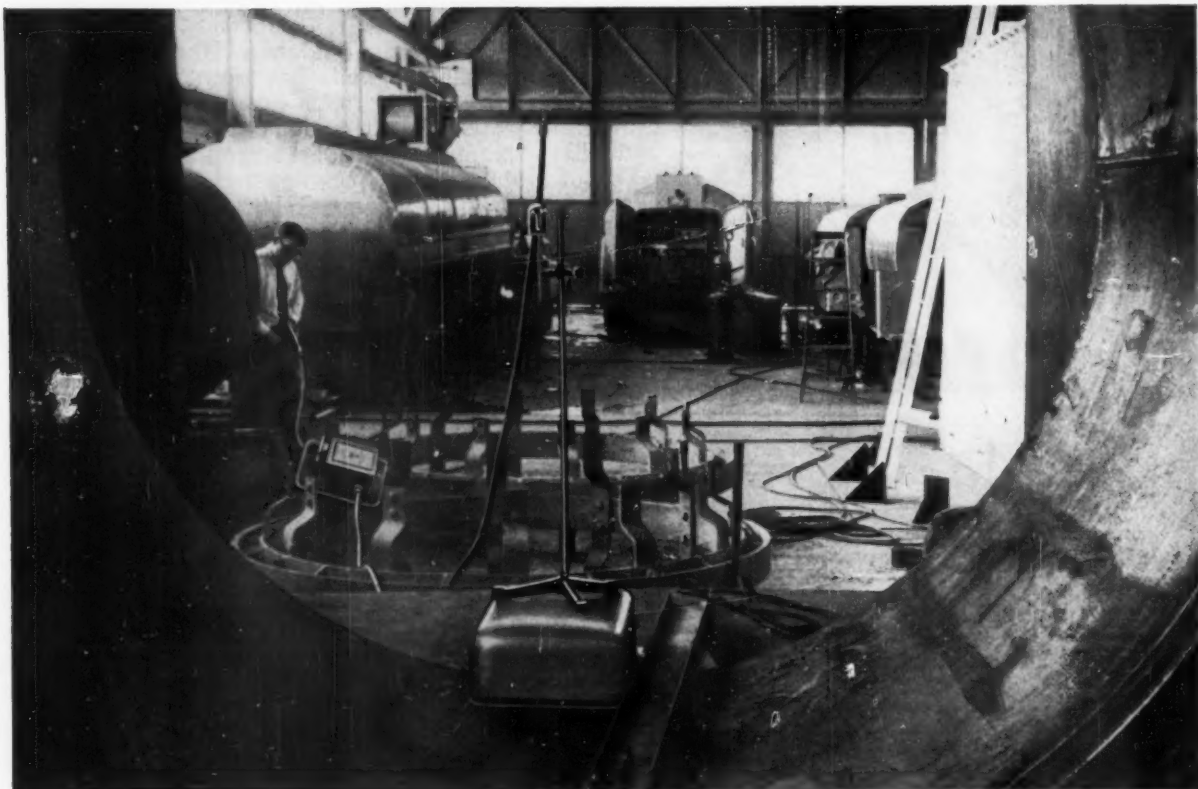
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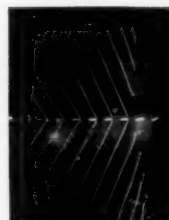
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COVER PHOTO:

One millisecond strobe multiple exposure of bullet striking nylon yarn. Twelfth ASTM Photographic Exhibit. R. J. Coskren, Fabric Research Laboratories, Inc., Dedham, Mass.



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Materials Research & Standards

The Explosion Age

"Now! Now!" cried the Queen. "Faster! Faster!" And they went so fast that at last they seemed to skim through the air, hardly touching the ground with their feet, till suddenly, just as Alice was getting quite exhausted, they stopped . . .

Alice looked round her in great surprise. "Why, I do believe we've been under this tree the whole time! In our country you'd generally get to somewhere else—if you ran very fast for a long time as we've been doing."

"A slow sort of country!" said the Queen. "Now here, you see, it takes all the running you can do, to keep in the same place."

Through the Looking Glass

THE SUSPICION GROWS that, at some time during the past decade or two, mankind followed Alice through the looking glass and now finds himself in a world where it takes all the running he can do to keep in the same place.

It used to be that a man could wake every morning of his life knowing, at least, what Age he lived in. Nowadays he had better check his morning paper first. As Glenn Seaborg said recently, "We have compressed centuries of environmental evolution into the past two decades. . . . Ages tumble one upon another so rapidly that only future historians can untangle them." What Age are we in now? Electronic? Atomic? Space? Thermonuclear? Automation?

Perhaps the best term is the Explosion Age. We are beset on every side by explosions—from population to thermonuclear. Everything is rocketing upward on an exponential curve.

World crises pile in upon us—we now have two or three on the fire at once. It almost makes one long for the good old days of the thirties, when there was a decent interval of months between threats to our civilization. Even the day of the leisurely war, it seems, is past. One visualizes the big one to come as being settled in a matter of days, instead of years.

We are told that we must get to the moon with all haste. Even the war to the death in which Western civilization reluctantly finds itself is called a "race." We are told that whole continents of feudal societies must be wrenched from the Middle Ages to the 20th century in the space of a few years. The new nations of Africa are struggling to compress millennia of Western evolution into less than one generation. The flint and the spear are to be quickly exchanged for the turret lathe and the nuclear warhead.

The catalyst in all this is, of course, the rise of modern science and the unfettered exploitation of scientific research. And one "unhappy harvest" of this fact, again according to Glenn Seaborg, is the "strange notions of those who hold that science is going too fast; that the clock should be stopped or even turned back." Dr. Seaborg rightfully points out that this cannot be done. "Once man dared to question the untested natural laws that ruled him, there was and is no running from the unrelenting pursuit of truth."

Granting this, one still feels the threat to one's identity as an individual human being. To the all-powerful troika of Big Business, Big Labor, and Big Government, we must add Big Science. In the shadow of these monoliths, we are in danger of forgetting that the world was not made for any of these, or for organizations at all; it was made for man. And the only place where this idea can be preserved is in the mind and consciousness of each man. This may be our heaviest responsibility in the trying period ahead—to keep alive, each as an individual member of the race, the inspiring and still revolutionary idea that the world exists for man.

A.Q.M.

Exposure Testing of Protective Paints for Metals

By C. A. LOMINSKA

THE EVALUATION of paints for their ability to provide protection against corrosion can be divided into three phases. The first phase occurs in the laboratory, where the paint is developed and where preliminary tests are made to determine its properties and usefulness. Such tests include salt-spray, high-humidity and temperature cabinets, immersion tests, and artificial weathering machines. All of these tests are designed to accelerate film breakdown. Results obtained with these accelerated tests have generally shown poor correlation with performance in the field. Valuable information on certain specific properties can be obtained from them, but to date no accelerated procedures have been designed which duplicate the physical and chemical changes in a paint film that develop gradually in the field under actual weathering conditions. These changes as the film ages apparently have a profound effect on the ultimate performance of the paint.

The second phase of paint evaluation is exposure-fence testing, a form of field testing which is the subject of this paper. Interest in field testing was greatly stimulated by the early work of ASTM from 1906 to 1913, when tests were conducted under the auspices of that society on the Havre de Grace bridge and at Atlantic City. The report of the results^{1,2} created a great deal of interest and comment in the paint industry. The Havre de Grace Bridge tests were actually service tests, since the paints were applied to sections of a railroad bridge used by the Pennsylvania Railroad Co. in its regular operations. The Atlantic City tests, on the other hand, were not service tests, since they were applied to test panels and mounted on an exposure fence.

Service testing is the third and final phase of evaluation, and, to some extent, the most important, since it is the phase that determines commercial acceptance. Service tests measure the

Exposure-fence testing is an important phase of the evaluation of a paint for its ability to protect metal against corrosion. A large exposure program requires convenient methods for handling the test specimens and simplified techniques for recording exposure inspection data. A number of recent developments for improving exposure techniques which are in use or under test at the National Lead Co. Paint Testing Station are described and illustrated.

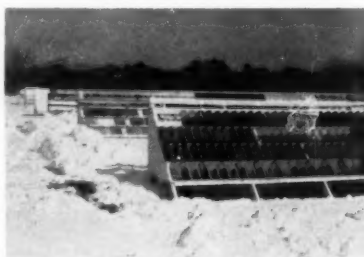


Fig. 1.—Exposure fence at 45-deg angle.

adaptability of a product over the entire range of variables that might be encountered in its intended use. There are some practical limitations on the scope of service tests that affect their usefulness as a part of a general evaluation program. A relatively large test area is required for the test to be truly representative of service conditions. This limits the number of tests that can be conducted. Since such tests are ordinarily made on an existing structure, application costs are likely to be high, because scaffolding or other expensive equipment may be required. Proper inspection of the tests may be a problem, since the structure is usually not under the control of the people conducting the tests. Consequently, the inspections have to be made at a time convenient to the owner so that there is no interference with his normal use of the structure.

Ordinarily, the main distinction between service testing and exposure-fence testing is that there is a definite attempt

in the latter to limit or control the variables, whereas, in service testing the variables are ordinarily considered as conditions that must be met and overcome if the product is to be successful in use.

The requirements for a test fence exposure program vary with a number of factors, for example, the nature of the product. A company that manufactures only paints would have a less complex problem ordinarily than a company manufacturing raw materials for use in paints. The development of a new raw material may involve several years of exposure testing before its basic properties are determined. Further testing is ordinarily required in order to determine its usefulness and limitations. The paint manufacturer, on the other hand, is provided with basic information, and his exposures would tend to approach service testing. Other factors which have an influence are, the range of interest of the company and the extent of its research program.

Exposure Fences

The term "exposure fence" is used here in a very broad sense and includes any means for mounting test specimens. The most practical type of fence for atmospheric exposure is the kind that is inclined at an angle of 45 deg from the vertical (Fig. 1). The principal advantage over the vertical fence is that failure of metal-protective paints develops more rapidly because

C. A. LOMINSKA was graduated from the law school of St. John's University in Brooklyn. Subsequently, he attended Brooklyn Polytechnic Inst. He began his career in the protective coatings field in the research laboratories of the Titanium Pigment Co. in 1931. From 1931 to 1936 he was engaged in exposure testing work for that company. In 1936 he transferred to the National Lead Co. and since that time has been in charge of his company's activities at the exposure station at Sayville, Long Island.

¹ "Report of Subcommittee II on Inspection of Havre de Grace Bridge," *Proceedings, Am. Soc. Testing Mats.*, Vol. XV, Part I, p. 189 (1915).

² "Report of Subcommittee IV on Inspection of Steel Plates at Atlantic City," *Ibid.*, p. 214.

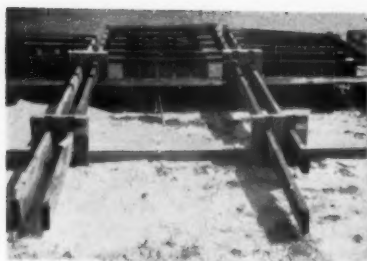


Fig. 2.—Movable type of rack for carrying test panels.

the test panels receive more sunshine than they do at vertical exposure. However, the rate is not increased to the extent that it could be considered an accelerated test. Actually, it is representative of some conditions of exposure. For example, in bridge construction there are frequently structural members that are inclined at angles varying from the horizontal to the vertical. Another advantage of the 45-deg fence is that it is simpler to mount test specimens at this angle than it is to mount them vertically.

Marine Exposure Racks

Racking of test panels for marine or fresh-water immersion tests presents special problems and is largely governed by the natural characteristics of the site and its degree of exposure to the elements.

At the National Lead Co. Marine Basin a convenient system has been devised for mounting test specimens. The marine basin test area is inclosed by bulkheading except for two openings which allow free circulation of the water. It is, therefore, well protected against stormy weather and it is practical to use light construction materials for mounting the test panels. In this system, the supporting rack is movable and projects beyond the bulkhead and over the water. The test panels are mounted on the bottom member of a rectangular frame or attached to a wood bar that fits into slots cut into the movable rack (Fig. 2). The bar-type mounting, shown in Fig. 3, is used for panels exposed above the water, while the frames are used for panels at half tide or for complete-immersion exposure. The

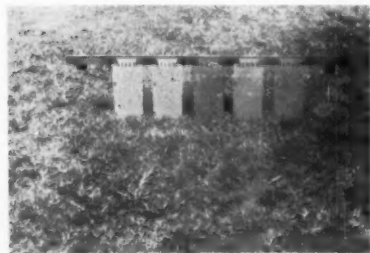


Fig. 3.—Bar type of rack for holding test panels above water.

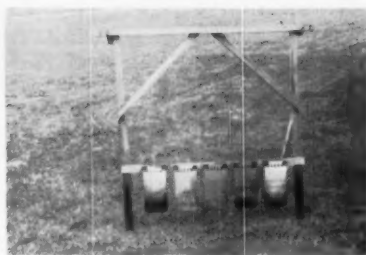


Fig. 4.—Panels mounted on rectangular frame for half-tide immersion.

supporting rack can be retracted and the frames or bars easily removed for examination of the test panels. The depth of immersion is controlled by the length of the side pieces of the rectangular frame that holds the panels (see Fig. 4).

The mounting of test specimens in the fresh-water basin is somewhat similar to the system used in the marine basin except that a raft is used (Figs. 5 and 6). Parallel slotted timbers attached to the raft are spaced so that the rack holding the test panels can be suspended between them.

An important consideration in the mounting for exposure of all metal-protective paint test panels is the prevention of galvanic effects. This is handled at the atmospheric station by constructing all parts of the fence that are in contact with the test panels of wood (see Fig. 7). At the marine station and the fresh-water basin wooden racks are also used. However, the system of attachment of the panels to the racks at these locations requires brass bolts. These bolts are separated from the metal test panels by washers and separators made of insulating material (see Fig. 7).

There are a number of other sources of galvanic effects. One that is quite common occurs in testing antifouling paint containing cuprous oxide. If damage to the paint film exposes metal, the primer loses its effectiveness as a barrier coat in that area. Such damage usually occurs at the corner or edge of a test specimen.

The choice of test specimens, the surface condition, and the type of surface preparation of the specimens are

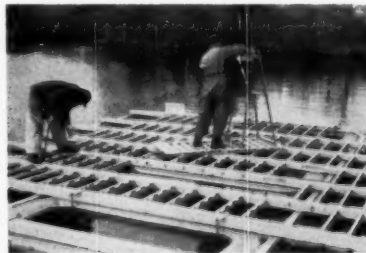


Fig. 5.—Fresh-water immersion panels suspended from a raft.



Fig. 6.—Racking system for fresh water immersion tests.

of great importance. It has been demonstrated many times that a paint which shows superiority on a perfectly cleaned surface will not necessarily show the same superiority when exposed on a partially or completely rusted surface. The choice should be governed by the general nature of the exposure problem and the type of information sought. If the type of information required is the performance of a material under service conditions, then the choice of test specimen and its surface preparation should be representative of the conditions encountered in actual use. This ordinarily includes numerous variables. On the other hand, if the test is part of a research project, and there is no prior knowledge of the properties of the material, then a definite attempt should be made to limit variables in the selection of test specimens. Steel sand-blasted to bare metal produces a surface that has the least possibility for variation and can be considered as the best type of surface preparation for this purpose.

Practical factors, such as the length of time before exposure results are obtained, must also be considered. Frequently, in the exposure work at Sayville, test specimens with surface con-

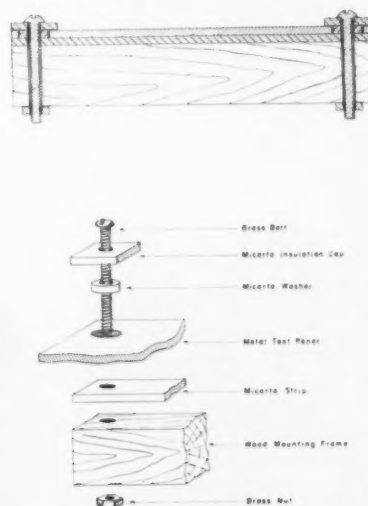


Fig. 7.—Attachment assembly for the prevention of galvanic effects on marine test panels. (top) Section through head assembly. (bottom) Exploded assembly.

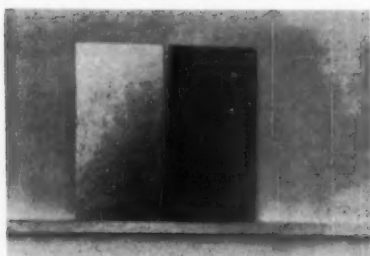


Fig. 8.—Left, new galvanized steel panel; right, galvanized panel that has been sand-blasted to steel in circular areas and then allowed to rust.

ditions varying from clean sandblasted steel to badly rusted steel are used for each test. This, of course, adds to the number of specimens involved in each test, but the advantage is that some information on performance can be obtained in a relatively short time. In recent years many of the tests have been made with angle iron or hot-rolled steel plates which have been sandblasted to remove all mill scale and then placed out in the field and allowed to rust completely before painting. This provides a surface with uniform active corrosion present and without mill scale, which introduces a variable that is difficult to control. Duplication of exposure results with this type of specimen has been very good.

The painting of galvanized steel, and consequently the selection of specimens for exposure tests, presents problems that differ from those encountered in the painting of ordinary steel. There are three conditions to consider: (1) new galvanized steel, (2) galvanized steel that has been weathered but has not

deteriorated to the extent that corrosion has taken place, and (3) galvanized steel that has weathered to a stage where some corrosion is present. The first two conditions present no problems as far as test specimens are concerned. Exposure of new galvanized steel for 6 months on a 45-deg fence will weather it sufficiently so that no lack of bonding of the paint to the surface will be encountered. The only precaution necessary for new galvanized steel is that an adequate cleaning procedure should be followed so that grease or other contaminants are removed. The third condition, where the steel is partially rusted, is the most troublesome. It is very difficult to procure partially rusted galvanized steel that is uniformly rusted so that a fair comparison can be made among the test panels.

A procedure for solving this problem is now under test at the Sayville Station. In this procedure new galvanized steel panels are lightly sandblasted over their entire area to remove the high gloss that is normal for new galvanized steel. A steel mask the same size as the panel with two circular holes cut through it is then placed over the panel. The circular areas are then heavily sandblasted so that all the zinc is removed and the bare steel is visible. The panels are then placed out of doors and allowed to weather. In two or three weeks the completely sandblasted areas rust badly and the lightly blasted area develops a slight white chalk typical of weathered galvanized steel (Fig. 8). The advantages of this type panel are that these conditions can be produced in a relatively short time, and the rusted areas in a series of panels are uniform in size, location, and degree of rust.

A somewhat similar procedure is being tested for use in repaint projects. In this type of testing, as in the case of rusted galvanized steel, it is difficult to obtain test specimens that have weathered paint with comparable areas of corrosion present. In this situation there is the added problem that the composition of the weathered paint should be the same for all tests. Preparation of the test panels must be started at least 6 months prior to the date it is planned to use them. Pieces of angle iron are used for the test specimens. The number required for a particular test are given a coat of standard primer and placed in the field and allowed to weather for approximately 6 months. Areas of standard size on these angles are then sandblasted to remove the paint, using a mask in the same manner as that described for the galvanized panels. The angles are placed in the field and the sandblasted area is allowed to rust completely. The specimens are then ready for application of the test paints.

Application

It is common practice in painting steel to use one or more coats of primer followed by one or more finish coats. Anticorrosive pigments are ordinarily included in the primer. The formulation of the finish coat depends upon the type of structure, the environmental conditions to which it will be subjected, and the length of service required. The time required for the complete system to fail will be governed by the environmental conditions and other factors. In atmospheric exposure of paints on clean steel, five or more years may be required before sufficient failure

Metal Protective Paint							
INSPECTION RECORD							
		Fence 27 Spec 12		Date Exposed April 24, 1953 Exposure Atmospheric 45° Project No. 58-11A			
		Location Sayville					
Test No.	Gloss	Chalking	General Appearance	Blistering	Corrosion	Cracking or Checking	Comments
8019A	7 4 1	10 9 9	10 9 9	10	10 9 9	10	
8020A	4 4 1	10 7 6	10 8 6	10	10 8 7	10	
8021A	6 4 2 1	10 9 9	10 7 5	10	10 9 6	10	
8022A	6 4 2 1	10 6 6	10 7 7	10	10	10	
8023A	6 4 2 1	10	10	10	10	10	
8024A	7 4 4 1	10	10	10	10	10	
8025A	4 1	10 8 7 7	10 9 9 7	10 8 6	10 6 4 1	10	
8026A	4 2 1	10 8 7 7	10 9 8 7	10 9	10 8 7	10	
8027A	7 6 3 1	10 9	10 9	10	10	10	
8028A	7 2 1	10 9 8	10 9 8	10	10 9	10	
8029A	7 1	10 9 8 8	10 9 9 7	10	10 8 8	10	
8030A	7 3 1	10 9 9	10 7 7	10 9	10 7 7	10	

NOTE.—Blank spaces which precede a rating of 10 also represent ratings of 10.
Fig. 9.—Specimen inspection record for metal-protective paints under atmospheric exposure.

TABLE I.—WEIGHT LOSS DUE TO CORROSION, PAINTED STEEL TEST PANELS.

Paint Rating	Weight Loss, g	Paint Rating	Weight Loss, g
1.....	1.9	9.....	16.2
2.....	10.1	10.....	18.0
3.....	10.7	11.....	18.3
4.....	12.3	12.....	24.4
5.....	12.5	13.....	28.6
6.....	13.3	14.....	31.4
7.....	13.7	15.....	33.9
8.....	14.4	16.....	59.7

NOTE: Data taken from an actual series of 16 points exposed at Sayville marine basin on sandblasted 6- by 12-in., No. 12 gage hot-rolled steel panels for a period of 15 months at half-tide immersion. The panels were coated on all sides with the test paints.

develops to justify any conclusions from the test.

In order to gain some information at an earlier date than the time required for failure of the complete system, most test panels at the Sayville Atmospheric Station are divided into four test areas. Areas 1 and 2 receive one and two coats of primer, respectively. Areas 3 and 4 receive one and two coats of the same primer, respectively, and a finish coat. In this way information can be obtained on primer performance with and without a topcoat and, since each coat is ordinarily 1.5 mils thick (dry film), the effect of film thickness can also be determined.

At the marine test station and the fresh-water basin, a complete paint system is ordinarily applied over the entire test area for all immersion tests, because the special environmental factors require a complete system for adequate protection, and the time interval for failure of a complete system is much shorter at these exposures.

Inspections

There is considerable variation in both the descriptive terms and the types of forms that various commercial exposure stations use in reporting exposure test results. Descriptive terms such as, "slight," "considerable," and "bad," referring to particular conditions such as "corrosion," "blistering," "cracking," etc. are satisfactory if the exposure program is small. However, if a large number of tests are involved the data become difficult to report in a clear manner. A numerical system of rating in which the tests are rated from "10," which represents no failure, to "0," which represents complete failure, has a number of practical advantages. For example, they are simple to record, they can be totaled or averaged, and the tests can be ranked in their order of superiority. In using this system of rating, superiority is indicated by the highest total.

An inspection record form designed for use at Sayville (Fig. 9) provides inspection space for a total of 12 inspections of 21 tests on a standard size sheet of paper. This form does not provide space for formulations or other descriptive data relative to the

paints. There are differences of opinion whether or not this is an advantage. Many investigators feel that the inspector may be influenced in his rating if the composition of the paint is visible during the inspection. The main advantage in having a number of tests on one inspection form is the ease of making comparisons of performance of the paints in a series of tests. Some consideration should be given to this phase in laying out the tests so that related tests can be compared easily. In many cases they can be grouped so that all of a related group are on a single inspection sheet.

At the marine station a special procedure has been developed, in addition to visual ratings, for determining the amount of corrosion. Visual ratings are based primarily on the surface area corroded relative to the entire area of the test panel. This may not be a complete evaluation of corrosion, particularly on marine test panels. Pitting corrosion frequently occurs, and deep pits can destroy a considerable amount of metal without much visible corrosion. In this procedure, all the steel test panels are weighed and the weight is recorded before the test paints are applied. At the conclusion of the tests, the panels are sandblasted to remove the paint that is left and any corrosion products that are present. The panels are again weighed and the amount of metal lost due to corrosion is determined by comparison with the original weight.

Table I shows actual weight losses due to corrosion obtained by the procedure outlined above. In following this procedure for the removal of old paint film and corrosion products by sandblasting, some of the noncorroded metal of the test panel is removed, as might be anticipated. Checks by removal of the paint from weathered test

panels that had no corrosion present show that there is a loss of metal ranging from 0.5 to 1.5 g for test panels with a total surface area of 1 sq. ft. This loss should be taken into consideration, naturally, in the evaluation for corrosion resistance.

Tests have been conducted at the Sayville marine station to determine the corrosive effects of the salt water at this location on uncoated and unprotected steel panels. The rate of metal loss due to corrosion of unpainted steel is quite rapid when exposed in this environment and varies depending upon the type of exposure. The corrosion rate at half-tide immersion is more than twice that under complete immersion. Apparently, the greater supply of oxygen, which is an essential element of corrosion, available in this type of exposure hastens the process of corrosion. The tests were conducted for a 3-month period. The results in Table II show good correlation among the five test specimens in each group. Maximum variance from the average is 1 g for the half-tide panels and 0.8 g for the complete-immersion panels.

Weather

Weather conditions at the test site are an important factor that must be considered in assessing paint performance. The accumulation of data over a period of years is essential in order to determine normal conditions for the location and to recognize departures from such normal conditions. At Sayville, weather instruments were installed at the atmospheric exposure station a number of years ago to record weather information automatically.

Table III presents a compilation of data on solar radiation for a period of years at this location. Data on temperature, precipitation, wind direction, and relative humidity have been compiled in a similar manner.

Salt-Water Conditions

Salt-water immersion tests are primarily influenced by the salinity of the water, its pH, and temperature range. Oxygen content is undoubtedly another important factor. These conditions not only have a direct chemical effect but also have an indirect effect, since they have an important influence on plant and animal growth in the water. Such

TABLE II.—WEIGHT LOSS DUE TO CORROSION IN UNPAINTED STEEL PANELS.

Group I, Half-Tide Immersion		Group II, Complete Immersion	
Panel Number	Weight Loss, g	Panel Number	Weight Loss, g
1B.....	50.2	1C.....	22.2
2B.....	49.5	2C.....	20.9
3B.....	49.8	3C.....	21.2
4B.....	48.3	4C.....	21.6
5B.....	49.0	5C.....	21.3
Average for five specimens.		Average for five specimens.	
49.2		21.4	

NOTE: Both groups were exposed simultaneously at the Sayville marine basin for a three-month period. Five identical 6- by 12-in., No. 12 gage sandblasted hot-rolled steel panels were used for each test.

TABLE III.—SOLAR RADIATION, MONTHLY TOTAL LANGLEYS.^a

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Total
1950...	3098	5036	10 211	10 923	13 174	16 887	15 476	13 529	9 443	8 777	5233	4236	116 023
1951...	4588	6816	9 944	13 703	16 764	15 325	16 454	14 709	11 968	8 359	5527	4718	128 875
1952...	4893	8306	9 424	11 089	15 967	17 397	18 159	14 009	9 593	9 593	5778	4398	131 144
1953...	4593	7455	9 209	11 850	13 388	18 887	18 522	15 741	13 581	8 706	4978	4167	131 077
1954...	4430	7787	11 832	14 341	13 117	17 765	18 424	14 287	10 724	9 476	5739	4849	132 771
1955...	6589	7297	11 160	11 763	19 187	16 535	17 424	15 182	12 317	8 652	6023	5225	137 354
1956...	5225	6773	10 396	13 086	17 160	17 075	15 007	15 249	11 150	10 342	5811	3564	130 838
1957...	5504	7172	11 388	13 519	11 709	19 766	19 684	16 119	12 778	10 202	5893	4584	144 317
8-yr Average...	4865	7080	10 446	12 534	15 808	17 455	17 394	14 853	11 762	9 263	5623	4468	131 550

^a U.S. Weather Bureau Designation: 1 g cal per sq cm.

growth can have a definite influence on paint performance, particularly when they become attached to the paint film.

Since the marine station is part of a natural bay area with free flow and circulation of water, there is, of course, no means of controlling the conditions any more than there is any method for controlling atmospheric conditions. Even though there is no means for controlling these things, it is still well to know the conditions under which the tests were conducted. It affords a means for comparison with other test locations, and since, control paints are ordinarily included with each series, it is also possible to determine whether or not slight changes in these conditions from year to year have any effect on duplication of results.

Salinity, temperature, and pH are determined weekly at the marine station

except during the winter months when such tests are suspended. Data on salinity over a 10-yr period are shown in Table IV and are typical of the form used in accumulating information on the characteristics of the water at the marine basin.

Progress in exposure testing of paints,

like any program of research and development, is largely dependent upon the test methods employed and the accuracy and efficiency of such methods. Therefore, it is essential that these testing methods and techniques should be given constant consideration and improved whenever possible.

TABLE IV.—MARINE BASIN WATER SALINITY—MONTHLY AVERAGE, PARTS PER THOUSAND.

Year	April	May	June	July	Aug.	Sept.	Oct.	Nov.	8-Month Average
1948...	21.3	21.9	20.7	20.0	20.0	21.4	23.4	23.7	21.6
1949...	20.5	21.1	20.4	23.1	24.0	23.7	24.5	24.6	22.7
1950...	23.8	22.8	21.8	22.9	22.9	22.8	24.4	24.9	23.3
1951...	21.8	21.7	21.7	22.4	21.7	24.9	21.6	21.0	22.1
1952...	18.6	18.4	18.7	17.1	18.3	18.8	20.0	21.7	19.0
1953...	17.2	16.5	18.1	19.5	19.4	19.4	21.2	22.4	19.2
1954...	23.1	22.6	22.9	20.3	24.5	22.3	20.8	22.1	22.3
1955...	23.5	26.1	23.6	24.4	24.2	23.7	22.2	21.6	23.7
1956...	21.4	21.0	21.9	20.9	21.2	21.2	22.6	23.6	21.7
1957...	20.3	22.3	22.5	20.3	26.5	26.1	25.4	25.3	23.6
10-yr Average...	21.2	21.4	21.2	21.1	22.3	22.4	22.6	23.1	21.9

Determination of Chlorides in Gypsum and Gypsum Products

By H. SURKEVICIUS

THE CHLORIDE content of gypsum and gypsum plaster is of interest in the plaster industry. A procedure for its determination is included in ASTM Methods C 26-60.¹ This method involves dissolving a 1-g sample in boiling water and titrating the chloride directly by Mohr's method. Owing to the low solubility of gypsum the solution so produced has a volume of about 500 ml, and if the chloride content is low it is impossible to obtain a significant titer. In this paper it is shown that an amount of chloride, calculated as NaCl, down to 0.01 per cent, can be determined in gypsum and gypsum products by digesting large samples in dilute HNO₃ and AgNO₃ and using the Volhard method for determining chloride.

¹ ASTM Methods of Testing Gypsum and Gypsum Products, 1960 Supplement to ASTM Book of Standards, Part 4, p. 43.

Procedure

Two commercial plasters, A and B, of good quality and low chloride content were used, and a sample of a reagent-grade CaSO₄ was used for some experiments. The standard solutions were prepared from analytical reagent grade materials, and cp concentrated HNO₃ was used.

Samples ranging in size from 5.0 to 100.0 g were transferred to beakers, and an amount of 0.05 N AgNO₃

greater than that required to convert the chloride to AgCl was added from a microburet. When measured amounts of chloride were added this was done before the addition of AgNO₃. Mixtures of concentrated HNO₃ and water that had been boiled in order to expel lower oxides of nitrogen and then cooled were slowly added to the samples. The mixtures were stirred gently, transferred to a hot plate, and heated to about 90 C while being stirred. More hot water

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TABLE I.—RECOVERY OF SODIUM CHLORIDE ADDED TO PLASTER B.

Test	Weight of Plaster, g	Average NaCl Content, g	NaCl Added, g	Additional Water Added, ml	0.05 N AgNO ₃ Added, ml	0.05 N NH ₄ CNS Used, ml	Acid Mixture		Total NaCl Found, g	Added NaCl Determined, g	Error in Determination, g	Error, per cent
							Concentrated HNO ₃ , ml	H ₂ O, ml				
No. 1...	10.0	0.0084	0.0165	100	15.00	6.70	20	100	0.0243	0.0159	-0.0006	-3.6
No. 2...	10.0	0.0084	0.0330	50	17.00	3.09	20	100	0.0407	0.0323	-0.0007	-2.1
No. 3...	25.0	0.0207	0.0165	100	15.00	2.14	35	100	0.0376	0.0169	+0.0004	+2.4
No. 4...	25.0	0.0207	0.0330	100	22.00	3.58	35	100	0.0539	0.0332	+0.0002	+0.6

NOTE—Tests 1 to 4 were done in triplicate.

was added (50 or 100 ml) and digested for 5 min, with occasional stirring. It is not advisable to boil the mixture or to digest for a longer period, as under these conditions the sample cakes and is difficult to wash free from AgNO₃. The mixture was filtered while hot, the residue washed three times with hot, 1 per cent HNO₃ in water, and then with hot water. The final volume was kept below 500 ml. The solution was cooled to below 25 C, transferred to a large porcelain dish, 3.0 to 5.0 ml of saturated

criticism that some AgNO₃ may be adsorbed by the undissolved solid. Regarding the latter point, it is worth stating that with one sample of reagent-grade CaSO₄ (not referred to in the tables) all the AgNO₃ was titratable.

In these experiments considerable variations were made in the amount of acid used and in the amount of sample, without affecting the results. However, it was found that low results were obtained if the amount of acid was reduced to 5.0 ml.

of 0.05 N AgNO₃ solution (5.00 to 20.00 ml) depending upon the chloride content. The amount of solution added should be 2 to 3 ml in excess of the amount required to precipitate all the chloride present. Cover the beaker with a watch glass and carefully add the acid mixture (25 ml concentrated HNO₃ plus 100 ml water) which had been previously boiled and cooled. When all the acid has been added, stir with a glass rod and heat gently on a hot plate for about 5 min. Then add 100 ml of hot water and digest for a further 5 min, stirring occasionally. Allow to stand on the bench for a few minutes and filter through a Buchner funnel. Wash three times with a 1 per cent solution of HNO₃ and finally with hot water until free from AgNO₃, cool to below 25 C, transfer to a large porcelain dish, add 3 to 5 ml of ferric alum indicator and titrate residual AgNO₃ with 0.05N NH₄CNS solution added dropwise or in small portions from a microburet and stirred vigorously with a glass rod until permanent faint reddish-brown coloration appears. Calculate as NaCl. One ml of 0.05 N AgNO₃ is equivalent to 0.002923 g of NaCl.

TABLE II.—DETERMINATION OF CHLORIDE IN PLASTER A.

Test	Weight of Sample, g	Acid Mixture		Additional Water Added, ml	0.05 N AgNO ₃ Added, ml	0.05 N NH ₄ CNS Added, ml	NaCl Found, g	NaCl, per cent ^a
		HNO ₃ , ml	H ₂ O, ml					
No. 1....	10	20	100	100	2.00	1.76	0.00076	0.0076
No. 2....	10	20	100	100	2.00	1.78	0.00064	0.0064
No. 3....	25	35	100	100	5.00	4.32	0.0018	0.0072
No. 4....	25	35	100	100	5.00	4.38	0.0020	0.0080
No. 5....	25	35	100	100	5.00	4.42	0.0017	0.0068
No. 6....	50	30	100	100	5.00	3.80	0.0035	0.007
No. 7....	50	30	100	100	5.00	3.77	0.0036	0.007
No. 8....	100	50	100	100	5.00	2.60	0.0070	0.007
No. 9....	100	30	100	100	5.00	2.61	0.0070	0.007

^a Samples did not dissolve completely.

(about 40 per cent) ferric alum in water was added as indicator, and the residual AgNO₃ titrated with 0.05 N ammonium thiocyanate (NH₄CNS) added dropwise or in small portions from a microburet until the end point was obtained. The amount of NH₄CNS required for blank determinations did not exceed 0.06 ml.

Results and Discussion

The results in Table I show that NaCl added to a large excess of plaster may be determined quantitatively by the type of procedure described above. Table II shows the results of the determination of small amounts of chlorides in a commercial plaster. The danger of a method in which the sample is not completely dissolved is that chloride may be locked up in individual crystals and the results for total chloride will be low. The figures in Table III show that the results have not been affected in this way. In tests 1 to 4 the plaster sample (5.0 g) dissolved completely in the dilute acid. The samples in the remaining tests did not dissolve completely, but the results of all the tests are virtually identical. This also disposes of the

Method Proposed

Solutions required:

1. AgNO₃ standard solution (0.05 N)
2. NH₄CNS standard solution (0.05 N)
3. One per cent solution of HNO₃ in water
4. Ferric alum indicator (about 40 per cent weight per volume)

Weigh out 10 to 20 g of the sample into a 500 ml beaker and add an excess

Acknowledgment:

This investigation forms part of the program of work carried out within the Division of Building Research, C.S.I.R.O., and sponsored by Associated Fibrous Plaster Manufacturers of Australia.

TABLE III.—DETERMINATION OF CHLORIDE IN COMMERCIAL PLASTER B.

Test	Weight of Sample, g	Acid Mixture		Additional Water Added, ml	0.05 N AgNO ₃ Added, ml	0.05 N NH ₄ CNS Added, ml	NaCl Found, g	NaCl, per cent
		HNO ₃ , ml	H ₂ O, ml					
No. 1....	5.0	50	100	100	5.00	3.56	0.0042	0.084 ^a
No. 2...	5.0	50	100	100	5.00	3.56	0.0042	0.084 ^a
No. 3...	5.0	50	100	100	5.00	3.62	0.0040	0.081 ^a
No. 4...	5.0	100	150	100	3.00	1.60	0.0041	0.083 ^a
No. 5...	10.0	20	100	50	5.00	2.11	0.0084	0.084 ^b
No. 6...	10.0	20	100	50	5.00	2.11	0.0084	0.084 ^b
No. 7...	10.0	20	100	50	5.00	2.12	0.0084	0.084 ^b
No. 8...	10.0	150	100	50	5.00	2.14	0.0084	0.084 ^b
No. 9...	25.0	35	100	100	10.00	2.85	0.0209	0.084 ^b
No. 10...	25.0	35	100	100	10.00	2.74	0.0212	0.084 ^b
No. 11...	25.0	35	100	100	10.00	3.16	0.0200	0.080 ^b
No. 12...	50.0	50	100	100	20.00	5.54	0.0423	0.085 ^b
No. 13...	50.0	50	100	100	20.00	5.54	0.0423	0.085 ^b
No. 14...	50.0	50	100	100	20.00	5.50	0.0424	0.085 ^b

^a Except for insolubles in acid samples dissolved completely.^b Samples did not dissolve completely.

Technical Note

Bulb-Filling and Handling Aids for Ramsbottom Carbon Residue Test (ASTM Method D 524)¹

By J. HARRY TAYLOR²

THE MEANS described in the ASTM Method D 524¹ for filling the coking bulb are not satisfactory when highly viscous oils or asphaltic type residues are to be tested. The apparatus described here permits the bulb to be easily charged by means of a spring-loaded clip attached to a hypodermic syringe. Modified forceps with special tips allow easy handling of the bulb in and out of the furnace.

Filling Apparatus

The rack and syringes (Fig. 1) are used as follows: The plunger is removed from the syringe, the needle is attached, and a representative portion of the sample, liquefied by heating, is poured into the cylinder. With practice, the

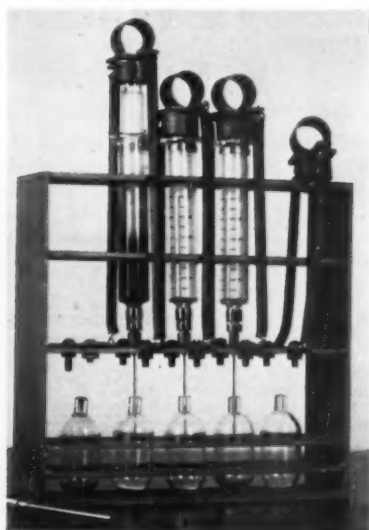


Fig. 1.—Bulb-filling apparatus.

¹ ASTM Method of Test for Ramsbottom Carbon Residue of Petroleum Products (D 524), 1959 Supplement to ASTM Book of Standards, Part 7, p. 33.

² Refinery Laboratory, Sun Oil Co., Marcus Hook, Pa.

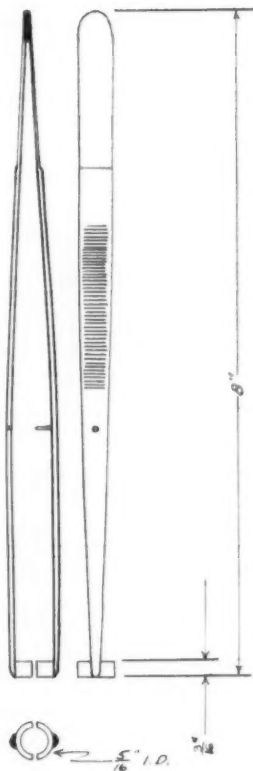


Fig. 2.—Modified handling forceps.

correct quantity is easily estimated. The plunger is lubricated with a drop or two of light oil and replaced in the barrel of the syringe. The syringe and its contents are placed in the rack with the needle projecting through the small hole in the middle shelf into the tared bulb. The spring-loaded clip is fastened over the end of the plunger. One to five samples are prepared and the whole assembly placed in an oven at such a temperature that all samples will be fluid and left until the contents have

transferred to the bulbs (usually 10 to 20 min). The assembly is removed from the oven, and the charged bulbs are placed in a desiccator for cooling and subsequent weighing. An infrared lamp may be used instead of an oven.

The rack may be constructed most easily of $\frac{1}{8}$ -in. brass plate cut approximately 2 in. wide and brazed or silver-soldered at the joints. Hole centers in the shelves must be directly aligned top to bottom. First and second shelf up are spaced $\frac{5}{8}$ in. apart and above the solid bottom of the rack and carry 1-in. holes. The third (middle) shelf, $2\frac{1}{4}$ in. above the second shelf, is drilled with $\frac{7}{32}$ -in. holes. The heights and hole-size of the two top shelves depend on the size of the syringe used. When used with a Leur-Lok "B-D" syringe (10-ml capacity) and an 18 to 20 gage needle 2 in. long, the fourth shelf is $2\frac{1}{4}$ in. above the center shelf and the top shelf $1\frac{1}{4}$ in. above the fourth and both carry $\frac{3}{4}$ -in. holes. Brass tabs (cut from $\frac{1}{16}$ -in. plate) are attached to the third shelf at the sides of each $\frac{7}{32}$ -in. hole, to which $\frac{1}{4}$ -in. diameter springs $4\frac{1}{2}$ in. long are fastened. These springs are connected at the top to $2\frac{1}{2}$ -in. long cross arms ($\frac{1}{16}$ -in. plate) carrying finger grips and caps made from $\frac{1}{2}$ -in. lengths of $\frac{3}{4}$ -in. ID brass pipe.

Modified Handling Forceps

To facilitate handling of the bulbs in the furnace, special tips are secured to the ends of straight 8-in. specimen forceps (Fig. 2). The tips may be made from a $\frac{3}{16}$ -in. length of $\frac{5}{16}$ -in. ID brass pipe. Place the pipe between the tips of the forceps with the hole parallel to the tips and braze or silver-solder in place, then saw the pipe lengthwise and file smooth. This device gives a positive hold on the neck of the bulb and does away with much "fishing" in the furnace.

The Determination of Organic Carbon on the Surface of Steel Sheets

By W. E. BOGGS and G. E. PELLISSIER

The low-pressure combustion method for the determination of carbon has been adapted for estimating the amount of organic residues remaining on steel sheets after various stages of commercial processing. This method can detect and determine 97 per cent of the carbon on steel sheets contaminated with known amounts of mill lubricants of known composition.

IN THE COMMERCIAL manufacture of sheet-steel products such as tin-mill black plate (the steel-sheet material used for tin plate), various electrolytic cleaning procedures are used for removing surface contaminants that may be introduced during the various stages of processing. Black plate is usually 0.010 in. thick, with an approximate composition of 0.07 to 0.10 per cent carbon and 0.30 to 0.45 per cent manganese, and it usually contains 0.006 to 0.020 per cent phosphorus, 0.020 to 0.030 per cent sulfur, 0.008 to 0.010 per cent silicon, and small amounts of other residuals. During an investigation of the effectiveness of different commercial cleaners and cleaning processes, it was necessary to devise a means for estimating the amount of organic contamination, that is, the amount of oil and grease from rolling lubricants and other sources, that might remain on the steel sheet after mill cleaning.

One way to estimate the amount of oil and grease remaining on the surface of the steel sheet is to wash a large surface area with a suitable organic solvent and then to volatilize the solvent and weigh the oil and grease picked up in the washings. Such a procedure is time-consuming and requires a large amount of steel sheet and a large volume of organic solvent. Furthermore, a semi-drying oil, such as cottonseed oil, cannot be extracted completely in organic solvents once it has aged for a few days.

Because of the difficulties encountered in the solvent-extraction technique, it appeared that a method involving surface oxidation of the carbonaceous con-

taminants, *in situ*, coupled with micro-determination of the carbon oxides evolved, would be a useful measure of the amount of organic contamination, because it would give more complete and reliable results and would require fewer samples.

A vacuum-combustion method¹⁻³ for determining small concentrations of carbon in steel has been available for many years. This method, which is accurate to $\pm 3.6 \times 10^{-6}$ g of carbon (0.0007 per cent carbon in a 0.5-g steel sample), seemed most suitable for adapting to the determination of surface carbon because of its high sensitivity and directness. It was necessary to modify the technique to selectively remove and oxidize the organic surface contaminants without appreciably decarburizing the bulk of the low-carbon steel strip.

It was recognized that the combustion temperature had to be high enough to provide complete combustion of the organic materials on the surface and still be low enough to avoid appreciable diffusion of carbon from the interior of the steel sheet to the surface, where it might be oxidized and be determined as organic carbon.

Accordingly, an apparatus was designed for the low-temperature, low-pressure combustion of organic carbon on the surface of sheet steel at temperatures for which the diffusion rate of carbon in the steel to the surface is low. Essentially, the apparatus consists of a vacuum system in which purified oxygen can be circulated over a steel specimen at controlled temperature; a catalyst furnace in which any pyrolyzed hydrocarbon fragments are completely oxidized to carbon dioxide and water; and traps in which the water and carbon dioxide are separated from the oxygen stream for determination.

Apparatus and Procedure

The design of the apparatus is shown in Fig. 1. The specimen is coiled, to provide a large surface area in a small volume, and then placed in the cold section of the furnace tube at the right of the combustion furnace, F_1 . The system is evacuated, and oxygen passing through the copper oxide heater, F_2 , and the Ascarite trap, T_3 , for purification, is introduced through a stopcock, S_{10} , until a pressure of 10 mm H₂ is reached. The specimen is then drawn into furnace F_1 (500 C) with a magnet, and oxygen at a pressure of 10 mm Hg is circulated over it for 10 min. All the carbonaceous gases are converted to carbon dioxide and water in the heated palladium-asbestos catalyst, F_2 . The water formed in the combustion is

W. E. BOGGS received his B.S. in chemistry from Carnegie Institute of Technology in 1949 and has since done graduate work in chemistry and metallurgy at the same school. He has been a chemist at the Applied Research Laboratory of U. S. Steel Corp. since 1951. Until 1957, he operated a laboratory devoted to microchemical analyses. Among the problems encountered during this period was the separation and determination of chemical contaminants on the surface of steel strip. Since 1957, Mr. Boggs has been conducting a study of the mechanisms of oxidation of metals.

G. E. PELLISSIER obtained a B.Chem. degree in 1936 and an M.Chem. degree in 1938 from Cornell University, and continued graduate work at Carnegie Institute of Technology from 1938 to 1941 in metallurgy. He was an industrial research fellow in powder metallurgy at Stevens Institute of Technology during 1941-1942. Then he was associated with a special project at Columbia University that became part of the Manhattan Project. In 1945, he joined the Research Department of Carnegie-Illinois Steel Co. to work on applications of new physical and analytical methods to the improvement of steel quality and process control. He was appointed chief of the Physics and Analytical Chemistry Div., Applied Research Laboratory, U. S. Steel Corp. in 1947, and since 1959 has been organizing a new advanced applied research group in that laboratory.

¹ L. A. Wooten and W. G. Guldner, "Determination of Carbon in Low-Carbon Iron and Steel," *Industrial and Engineering Chemistry* (Analytical Edition), Vol. 14, p. 835 (1942).

² W. M. Murray and S. E. Q. Ashley, "Determination of Carbon by the Low-Pressure Combustion Method," *Industrial and Engineering Chemistry* (Analytical Edition), Vol. 16, p. 242 (1944).

³ "Carbon by the Low-Pressure Combustion Method," Methods for Chemical Analysis of Electronic Nickel (E 107-56 T), ASTM Methods of Chemical Analysis of Metals, p. 292 (1956).

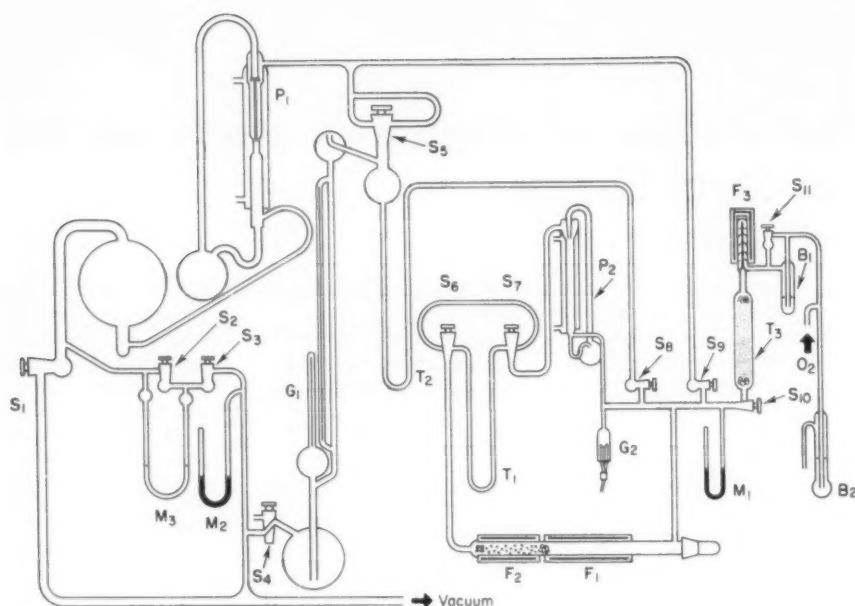


Fig. 1.—Apparatus for determining carbon on the surface of steel sheets.

condensed in trap T_1 , which is cooled with a mixture of solid CO_2 and 1-methoxy, 2-propanol. After the 10-min combustion period, the combustion gas is allowed to flow into the measuring system through trap T_2 , which is cooled in liquid nitrogen. Carbon dioxide condenses in this trap, whereas the excess oxygen passes through and is pumped out of the vacuum system with the mercury diffusion pump, P_1 .

The condensed carbon dioxide is allowed to expand into the measuring system of the apparatus between stopcock S_4 and stopcock S_5 . The amount of carbon in the combustion gas is then calculated from the pressure of the carbon dioxide at room temperature, as measured with the McLeod gage, G_1 .

Results and Discussion

To validate the combustion method, a series of tests were made on materials of known surface-carbon content. By applying weighed amounts of stearic acid and palm oil (the carbon content and volatility of which had previously been determined) to uniformly cleaned steel surfaces, the effect of increasing the combustion temperature on carbon recovery from the surfaces was determined. Then, the contribution of carbon from the bulk-steel strip at various temperatures was estimated by first burning off the organic carbon until a constant small amount of carbon was detected at the end of each heating cycle, and by then raising the temperature in increments and determining the carbon recovered at each temperature. A combustion temperature of 500 C was chosen on the basis of these experiments, and the recovery of carbon from a series of steel specimens coated with known

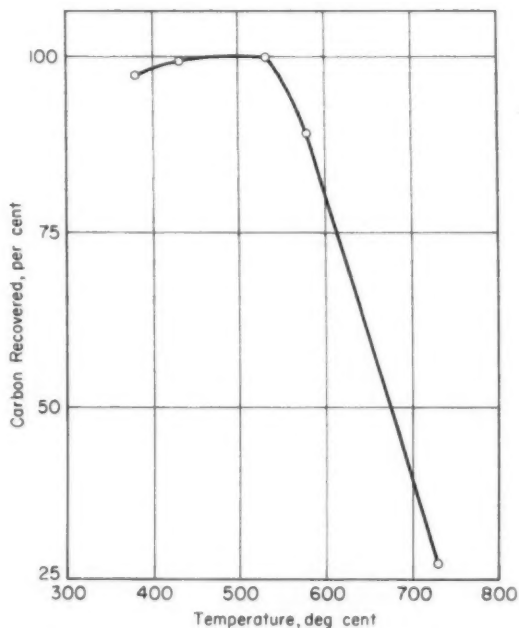


Fig. 2.—Effect of combustion temperature on the recovery of carbon from stearic acid.

amounts of palm oil and stearic acid was determined. The amount of carbon in the samples of palm oil and stearic acid used in this work was determined directly by a routine organic micro-combustion method. The reagent-grade palm oil contained 76.2 per cent carbon, and the stearic acid contained 75.0 per cent carbon.

The influence of the combustion temperature on the recovery of carbon from known amounts of stearic acid is shown in Fig. 2. As the temperature of the combustion furnace is increased from 370 to

530 C, the recovery of carbon approaches 100 per cent. Above 580 C, the recovery of surface carbon falls off sharply, and this behavior apparently is associated with the rapid oxidation and scaling of the steel surface. At the same time, the contribution of carbon from the bulk steel increased rapidly above 530 C (see Fig. 3). A combustion temperature of 500 C was chosen as the best temperature for selective oxidation of the organic contaminants on the steel surface because it gave nearly complete recovery of the organic surface car-

bon with a negligible carbon contribution from the bulk steel. Table I gives the recovery of carbon from rolling lubricants, graphite, and dibutylphthalate at 500 C. The average recovery of carbon from spectrographic graphite was only 0.54 per cent, whereas the recovery of carbon from organic sources was about 98 per cent. These recovery figures and all subsequent ones were corrected by subtracting the small systematic contribution of carbon from the bulk steel at 500 C (Fig. 3).

By means of mass-spectrographic analysis, the gas that is finally trapped and measured in the McLeod gage was found to be pure carbon dioxide. Thus,

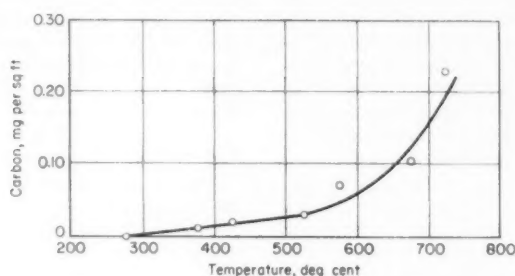


Fig. 3.—Effect of temperature on the contribution of carbon by the bulk steel.

the system used for separation of the water, carbon dioxide, and oxygen in the gas stream is successful. The weight loss of the lubricants due to volatilization in vacuum at room temperature amounted to less than 0.2 per cent by weight of the lubricant. This amount is negligible in the normal operation of the apparatus.

The total amount of organic surface carbon per specimen that can be determined in this apparatus ranges from 0.004 to 0.914 mg. This range corresponds to 0.03 to 6.58 mg carbon per sq ft of surface for the 2- by 5-in. panel of steel (20 sq. in. surface area) that is normally used in this analysis. For higher amounts of carbon such as those found on uncleaned sheets, smaller specimens are used.

TABLE I.—RECOVERY OF CARBON FROM TYPICAL ROLLING LUBRICANTS AT 500 C.

Lubricant	Lubricant Added		Carbon Recovered	
	Weight, mg	Weight Carbon, mg	mg	per cent
Stearic acid.....	1.214	0.910	0.864	94.8
	0.502	0.376	0.365	97.1
	0.351	0.263	0.255	97.1
	0.590	0.443	0.444	100.2
Average.....				97.3
Palm oil.....	0.838	0.639	0.625	97.9
	0.247	0.188	0.189	100.5
	0.740	0.564	0.550	97.5
Average.....				98.6
Graphite.....	1.525		0.0065	0.43
	1.531		0.0099	0.65
Average.....				0.54
Dibutylphthalate.....		0.521	0.513	98.6

The amount of organic surface-carbon contamination was determined on 45 specimens of finished commercial black plate. The results are listed in Table II. The average of these analyses was used as a norm in evaluating the level of contamination on subsequently produced lots of black plate, and for the evaluation of the effectiveness of experimental cleaning procedures. The average level of organic carbon on these 45 samples was 0.25 mg per sq ft of surface. The extremes were 0.16 and 0.47 mg per sq ft, and the 95 per cent confidence limits were 0.102 and 0.398 mg per sq ft.

Table III shows the effects of a typical commercial cleaning process used for the

TABLE II.—SURFACE CARBON ON COMMERCIAL STEEL SHEETS.

Coil	Carbon, mg per sq ft ^a		
	Specimen A	Specimen B	Specimen C
1.....	0.23	0.18	0.26
2.....	0.17	0.17	0.19
3.....	0.20	0.19	0.19
4.....	0.36	0.20	0.37
5.....	0.28	0.37	0.33
6.....	0.25	0.20	0.27
7.....	0.16	0.20	0.19
8.....	0.34	0.33	0.38
9.....	0.47	0.23	0.29
10.....	0.30	0.17	0.20
11.....	0.18	0.24	0.34
12.....	0.25	0.21	0.26
13.....	0.27	0.26	0.35
14.....	0.20	0.19	0.24
15.....	0.23	0.17	0.23

^a Average carbon = 0.25 mg per sq ft; standard deviation = 0.074 mg per sq ft; 95% confidence limits = 0.102 and 0.398 mg per sq ft.

process is normally conducted without lubrication. As the strip passes through the hard, high-carbon-steel temper rolls, a fine dust called "temper-mill snow" is produced. This "snow" consists of fine particles of iron, iron oxides, and carbon. Work at U. S. Steel Corp. shows that the carbon content is higher than would be expected from the bulk-carbon content of the strip or the temper rolls. The determinations given in Table III indicate that the source of

TABLE III.—THE EFFECT OF PROCESSING ON SURFACE CARBON.

Specimen	Surface Carbon, mg per sq ft
AFTER COLD REDUCTION	
1.....	4.49
2.....	6.11
3.....	9.98
4.....	9.79
5.....	23.01
6.....	3.59
Average.....	9.50
AFTER COMMERCIAL STRIP CLEANING	
7.....	0.95
8.....	1.43
9.....	0.78
10.....	0.69
11.....	0.45
12.....	0.60
Average.....	0.82
AFTER CONTINUOUS ANNEALING ^a	
13.....	0.30
14.....	0.32
15.....	0.47
16.....	0.53
17.....	0.39
Average.....	0.40
AFTER TEMPER ROLLING	
18.....	0.19
19.....	0.14
20.....	0.25
21.....	0.19
22.....	0.30
23.....	0.18
24.....	0.42
25.....	0.21
26.....	0.17
27.....	0.24
Average.....	0.23

^a In continuous annealing of steel strip, a single strand of steel is fed continuously through a heating zone, annealing zone, and cooling zone, at a speed such that the transit time through the high-temperature (about 1300 F) annealing zone is about 150 sec. The atmosphere in the furnace is reducing, and its composition may range from 2 to 10 per cent hydrogen in nitrogen.

the excess carbon must be surface-carbon contamination of the strip.

Hudson and Stragand⁴ found in an investigation of the gas-metal reactions occurring during the box annealing of low-carbon steel that considerable amounts of carbon monoxide and carbon dioxide are evolved from the steel during box annealing and that higher amounts of these and hydrocarbon gases are encountered when the steel surface contains appreciable amounts of organic material such as cold-reduction lubricants. Surface-carbon analyses, performed by the described method, indicated that the amount of surface organic carbon was lowered by box annealing.

The experiment on the recovery of graphite artificially applied to the surface of steel strip specimens, showed that only about $\frac{1}{2}$ per cent of the graphite present was determined as CO_2

⁴ R. M. Hudson and G. L. Stragand, "Gas-Metal Reactions During Box Annealing of Low-Carbon Steel," *Transactions, Am. Soc. Metals*, Vol. 52, p. 135 (1960).

MR. ARBA THOMAS,¹—To my knowledge, this information has never been published before. However, at our Baltimore Works we made a similar study of stainless-steel wire of various grades. This study was brought about in an effort to determine the amount of surface contamination by wire-drawing lubricants. Sections of wire were heated in a stream of oxygen at 2000 F for a period of 10 min, and the carbon dioxide formed was determined by the regular combustion carbon method. Under these conditions there was surprisingly little oxidation of the wire surface, and we felt that the data ob-

under the prescribed conditions. This finding indicates that any elemental carbon or graphite that may form on steel strip during annealing as a result of complete degradation of organic contaminants would make only a very minor contribution to the amount of carbon determined. Thus, essentially only the organic carbon (probably in the form of "heavy" residue or tar) that remains on the strip surface after annealing is determined, and this was the objective in developing the method.

The surface-carbon apparatus was designed specifically for determining organic surface carbon contamination on normal 0.010-in. thick black plate. This thickness of steel strip easily can be coiled for insertion into the combustion tube. The low carbon content of the bulk steel and the relatively low temperature of combustion minimize the contribution of carbon from the interior of the steel. Thicker material can be analyzed for surface carbon, but it must be cut into $\frac{1}{2}$ or $\frac{3}{4}$ by 5-in. strips; this decreases the sensitivity of the determination almost fourfold. An at-

tempt was made to determine surface carbon on a zinc-coated product. Although reasonably good results were obtained with the first specimen, zinc condensed in the cold sections of the apparatus and also poisoned the palladium-asbestos catalyst. It was then necessary to clean the furnace tube with acid, replace the catalyst, and pump out the apparatus for several hours to remove the moisture. Thus, materials likely to contaminate the catalyst should not be analyzed in this apparatus.

This method gives 97 per cent recovery of carbon from known amounts of rolling lubricants on synthetically prepared samples. Since its development, the method has been used to help in the investigation of many problems related to the production of good quality steel products and has yielded information that was not readily obtainable by other means.

Acknowledgment:

The authors wish to thank R. D. Hinkel for his help in the design and construction of this apparatus.

DISCUSSION

tained gave a fairly accurate estimation of the residual drawing lubricant present on the wire surface. Wire that had been degreased gave carbon values on the order of up to 5 μg per sq cm. On wire that had not been degreased the values ranged from 50 to 100 μg per sq cm and upward.

The method proposed by the authors would also probably work very satisfactorily using the regular combustion carbon method with a conductometric finish.

MR. G. E. PELLISSIER (*author*).—The description of a similar study of

residual lubricants on drawn stainless-steel wire, conducted by Armco at their Baltimore Works, is interesting. However, it differs from the method that we have developed in one important aspect, namely, that regular high-temperature (2000 F or above) carbon combustion would undoubtedly oxidize an appreciable amount of the carbon existing within carbon steel strip (decarburation), as well as elemental carbon or graphite that may have formed on the surface as a result of annealing. This would be objectionable if the intent is to determine only the residual organic carbon on the surface.

Conference on Inspection of Steam Power and Nuclear Power Plant Components

INSPECTION OF steam power and nuclear power plant components is the subject of a one-day conference scheduled by the Society for Nondestructive Testing for Wednesday, October 25, 1961, in the new COBO Convention Hall in Detroit, Mich.

The conference is a part of a program held concurrently with meetings of the American Society for Metals, the American Institute of Mining, Metallurgical and Petroleum Engineers, and the Metals Show.

The following papers comprise the program:

Nondestructive Testing in Utilities Conventional and Nuclear Steam Generating Equipment—W. B. Bunn and E. S. Proctor, Combustion Engineering, Inc.

Quality Control in the Fabrication of Fuel Element Assemblies for the Hallam Nuclear Power Facility—B. H. Dixon, Atomics International.

Realistic Inspection of Power Plant Components to Reduce Service Failures—H. Thielsch, Grinnell Co., Inc.

Nondestructive Inspection of Turbine-Generator Parts During Manufacture and after Service—D. L. Sauer and R. G. Matters, Allis Chalmers.

Nondestructive Testing, a Maintenance Tool for the Power Plant—T. D. Carr and R. H. Zong, Philadelphia Electric Co.

Nondestructive Testing Methods for Metallurgical Analysis—J. A. Klapper, Ebasco Services, Inc.

Illustration and Discussion of Latest Nondestructive Testing Equipment and Techniques Used in Power and Nuclear Plants—presented by various manufacturers.

The program will also include a Panel Discussion on Nondestructive Testing Problems, for which industry is invited to submit specific questions to: Helmut Thielsch, Grinnell Co., Inc., 260 West Exchange St., Providence 1, R. I.

Effect of Specimen Geometry on Determination of Elongation in Sheet Tension Specimens^{*1}

By E. B. KULA and N. H. FAHEY

THE CURRENT interest in sheet material has emphasized the need for a more accurate understanding of the significance of ductility. This is especially true of elongation, which is the most common and, frequently, the only means used for assessing ductility of sheet materials. Unfortunately, elongation values depend on such geometrical factors as specimen thickness and width in addition to gage length and the inherent ductility of the material itself. As a convenience, a constant gage length and specimen width are used as the ASTM standard sheet tension specimen,² but this means that the elongation of specimens of different thicknesses are not strictly comparable. If an interrelationship between elongation, gage length, specimen width, and specimen thickness could be determined, either analytically or empirically, it would be possible to correlate ductility for specimens of widely different sizes and shapes.

The goal of this investigation was to develop an understanding of how specimen geometry affects elongation. It was recognized that the elongation of a tension specimen can be roughly divided into a uniform strain and a localized strain associated with the neck. Since the extent of the necked region varies with the specimen area, its contribution to the total elongation of a fixed gage length will also vary with specimen area. By applying a grid to the surface of the specimen, the elongations associated with the uniform strain and localized strain can be determined for various specimen geometries. Reported here are some results on how specimen width and thickness affect the elongation in a fixed gage length. The influence of reduced section length (shoulder restraints or stored elastic energy) has been neglected.

The influence of specimen thickness and width on the elongation in 2 in. was studied on copper, AISI 1020 steel, and heat-treated H-11 steel.

The results conform approximately to Templin's equation, $EI = CA^n$. The constant n , a measure of the variation of elongation in 2 in. with specimen area, is shown to be related to the logarithm of the ratio of the zero-gage-length (fracture strain) to the infinite-gage-length (uniform strain) elongations. A method is shown for predicting the elongation in 2 in. for a bar of any thickness (or width) from measurements on another bar of the same material. The reason for specimen area being of greater importance than absolute values of width or thickness in controlling elongation is demonstrated by studying the strain distribution near the fracture.

Review of Literature

There has been considerable interest in the past in the effects of specimen geometry on tensile properties and especially on elongation. The older European literature has been reviewed in *Handbuch der Werkstoffprüfung* (1),³ whereas much of the American literature was reviewed in a recent DMIC report (2).

Quantitative relations between elongation and gage length and cross-sectional geometry generally take two forms: (1) variation of elongation with gage length for specimens of a given cross-section, and (2) variation of elongation with specimen area in specimens with differing cross-sectional size or geometry or both but with the same gage length.

Equations relating elongation and gage length have been important because of the great number of gage lengths in common use and the desirability of comparing elongation values. In other countries, the gage lengths used for determining elongation vary from 3.54 to 10 times the specimen diameter for round specimens (1), and from 4 to 11.3 times the square root of the area for flat specimens. Even within one country, two or more gage lengths may be used. When the ratios of gage length to square root of area used in testing thin sheet and wire in this coun-

try are considered, even wider differences are found.

These equations generally recognize that the elongation is a maximum for a zero gage length. The zero-gage-length elongation can be calculated from the true fracture strain or reduction of area. From this maximum value the elongation decreases as the gage length increases and approaches a limiting value as the gage length approaches infinity. If creep and shoulder restraints could be avoided, this would be the strain at onset of necking, or the maximum uniform strain.

The dependence of elongation on specimen cross-sectional area has been recognized. This can be seen in the practice of designating gage length as some multiple of specimen diameter for round specimens. For rectangular specimens, gage lengths have been specified as a multiple of the square root of the area. Since the elongation depends primarily on the area and not the shape, to a first approximation, the cross-sectional shape can be considered as relatively unimportant. Templin (3) reported similar elongation values for variously shaped specimens, including tubular specimens, of the same area. Some of the equations relating elongation in a fixed gage length to specimen cross-sectional area are:

* Presented at the Sixty-fourth Annual Meeting, Atlantic City, N. J., June 26-30, 1961.

¹ The statements and opinions expressed in this article are those of the authors and do not necessarily indicate the views or policy of the Army Ordnance Corps.

² Tentative Methods of Tension Testing of Metallic Materials (E 8 - 57 T), 1958 Book of ASTM Standards, Part 3, p. 103.

³ The boldface numbers in parentheses refer to the list of references appended to this paper.

ERIC B. KULA received his undergraduate and graduate degrees in metallurgy from M.I.T. He has been a physical metallurgist at Watertown Arsenal Laboratories, Watertown, Mass., since 1956, where his interests have been in the fields of high-strength steels and mechanical metallurgy.

NORBERT H. FAHEY has been employed at Watertown Arsenal Laboratories since 1950. He worked as foreman of the Physical Testing Section while completing his undergraduate work in mechanical engineering at Northeastern University. Since this time his interests have been in the field of improvement of testing techniques in mechanical metallurgy.

Bauschinger (4):

$$El = El_0 + \frac{Q}{L} \sqrt{A} \quad (1)$$

Bertella (5):

$$El = C + \frac{Q}{Lm} A^{\frac{n}{m}} \quad (2)$$

Templin (3): $El = CA^n$ (3)

where:

El = per cent elongation,
 El_0 = per cent elongation measured on an infinitely long gage length,
 A = original area,
 L = gage length, and
 C, Q, m, n = constants.

All three equations show that the elongation increases with some exponential function of the area. Templin's equation does not consider variations in both gage length and area, so the term El_0 does not appear.

Materials and Procedure

Since contributions to elongation can ideally be considered to come from the two sources, the uniform elongation and the extension associated with the neck, the effect of specimen geometry on these quantities was to be determined. This was accomplished by applying a grid to the specimen surfaces photographically with a grid spacing of 20 lines to the inch along the reduced section and analyzing the distribution of strain throughout this region, with particular emphasis on the necked region. With this in mind, the materials used were selected because of their differences in uniform strain values. The materials used, each of which were individual heats, were hard-drawn copper, annealed copper, AISI 1020 steel, and H-11 tool steel. The copper and steel were obtained as $\frac{1}{2}$ in. thick by 2 $\frac{1}{2}$

in. wide bars in random lengths, and the H-11 steel was supplied in $\frac{1}{2}$ -in. sheet. After ensuring the homogeneity of the material by macroetching and hardness surveys, tension specimens of various thicknesses and widths were prepared from the $\frac{1}{2}$ -in. bar by slicing to the approximate thickness and then carefully grinding to size. Specimen thicknesses from 0.010 to 0.500 in. were prepared, with widths ranging from $\frac{1}{4}$ to 2 in. (see Fig. 1). This resulted in specimen width-to-thickness ratios of from 1:1 to 200:1 and areas ranging from 0.0013 to 1.00 sq in.

Tensile properties of the various materials used are summarized in Table I. The copper was received in the hard-drawn condition. The annealed copper was obtained by annealing the as-received material for 1 hr at 1200 F. Testing of both coppers was carried out after machining and an anneal of 2 hr at 400 F. The AISI 1020 hot-rolled steel was normalized at 1700 F prior to machining and annealing at 750 F for 2 hr. The H-11 tool steel was machined to size, austenitized in a salt pot at 1800 F for 20 min (after preheating at 1450 F), quenched in still air, and tempered twice, 1 hr each time, at 1050 F.

The head speeds of the testing machines were regulated so that all specimens were strained at an initial rate of 0.01 in. per in. up to the yield and then at 0.02 in. per in. to fracture.



$W = \frac{1}{4}, \frac{1}{2}, 1, 1\frac{1}{2}, \text{ and } 2 \text{ in.}$
 $t = 0.010, 0.020, 0.040, 0.080, 0.125, 0.250, \text{ and } 0.500 \text{ in. (In no case was } W/t < 1.)$
 $C = \frac{1}{2} \text{ in. for } W = \frac{1}{4} \text{ and } \frac{1}{2} \text{ in.; } 1 \text{ in. for } W = \frac{1}{2} \text{ in.; } 2 \text{ in. for } W = 1 \text{ in.; and } 2\frac{1}{2} \text{ in. for } W = 1\frac{1}{2} \text{ and } 2 \text{ in.}$
 $R = 1\text{-in. radius in all cases.}$
 $L_0 = 11.3 \sqrt{Wt}$, but minimum 2 in.
 $A = L_0 + 2W$.

Fig. 1.—Flat tension specimen.

Grids were applied to the surfaces of all the specimens prior to testing, with the lines spaced at 20 to the inch. Grids were put on the width surfaces of specimens $\frac{1}{2}$ in. or less in thickness and on both the width and thickness surfaces for specimen thicknesses of $\frac{1}{4}$ and $\frac{1}{2}$ in. (Fig. 2). As shown in this figure two local strains, namely, the width and longitudinal strains, can easily be measured on all specimens, and the thickness strain can be measured in the larger specimens. On the thinner specimens, the average thickness strains can be measured directly with a micrometer.

Test Results

The results plotted in Fig. 3 show that over a range of sizes there is a

TABLE I.—TENSILE PROPERTIES OF MATERIALS TESTED.

Material	0.2 Per Cent Yield Strength, psi	Tensile Strength, psi	Reduction of Area, per cent	Elongation, Total, per cent	Elongation, Uniform, per cent	Specimen Type
Copper, hard-drawn.....	34 800	37 000	69.2	30.0	7.0	0.357-in. diameter
Copper, annealed..	8 900	31 000	70.4	37.9	26.5	0.357-in. diameter
AISI 1020 steel.....	32 300	55 900	63.0	37.1	25.0	0.357-in. diameter
H-11 tool steel.....	231 000	250 900	...	8.8	4.0	$\frac{1}{2}$ in. by $\frac{1}{2}$ in.

RELATIONS:

LOCAL STRAINS:

$$e_1 = \frac{d_x' - d_x}{d_x}$$

$$e_2 = \frac{d_y' - d_y}{d_y}$$

$$e_3 = \frac{d_z' - d_z}{d_z}$$

AVERAGE STRAINS:

$$e_1 = \frac{L - L_0}{L_0}$$

$$e_2 = \frac{W - W_0}{W_0}$$

$$e_3 = \frac{t - t_0}{t_0}$$

WHERE:

$d_x', d_y', d_z',$
 $L, W,$ and t are the strained values of
 $d_{x_0}, d_{y_0}, d_{z_0}, L_0,$
 $W_0,$ and t_0

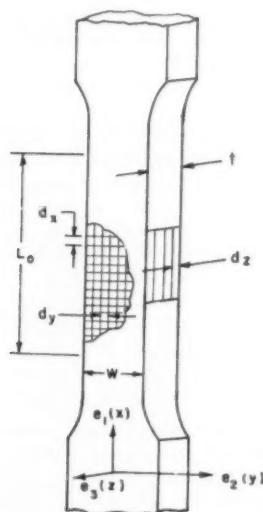


Fig. 2.—Strain directions in tension specimen.

linear relationship between the logarithm of elongation in 2 in. and the logarithm of area. There is considerable scatter, however, especially at low specimen areas. A consideration of the absolute width and thickness dimensions or the width-to-thickness ratios yielded no explanation for the scatter, except that the 0.010-in. and in some cases the 0.020-in. thick specimens tended to show low values of elongation. For a 0.010 or 0.020-in. thick specimen, a variation in thickness of ± 0.001 in. would have a great effect in localizing the strain from the very onset of plastic flow. Furthermore, there is the greater chance of damaging these specimens during machining such as by nicking. Many of the elongation values for these thin specimens are lower than the strain at maximum load as determined on standard-size round specimens, which suggests that initial dimensional variations caused nonhomogeneous strain. Also it must be recognized that tearing or other changes in the fracturing process may occur for these thin materials.

Equations 1, 2, and 3 relate elongation to some power of the area. It must be realized that for a specimen with an area approaching zero the elongation

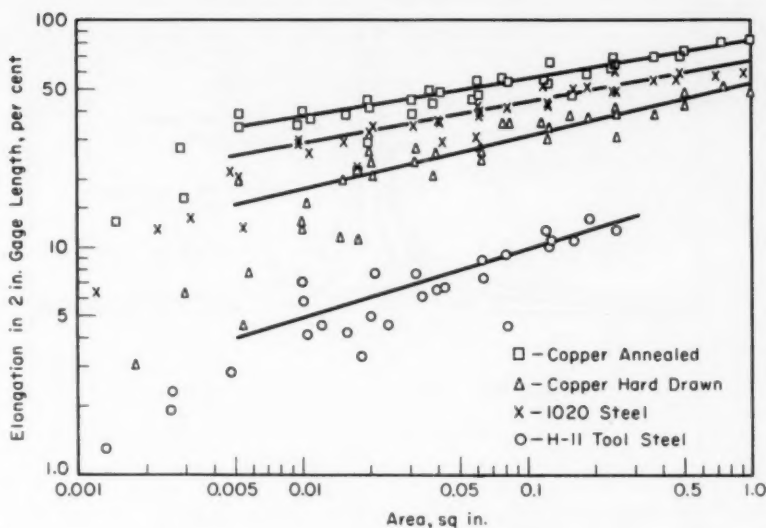
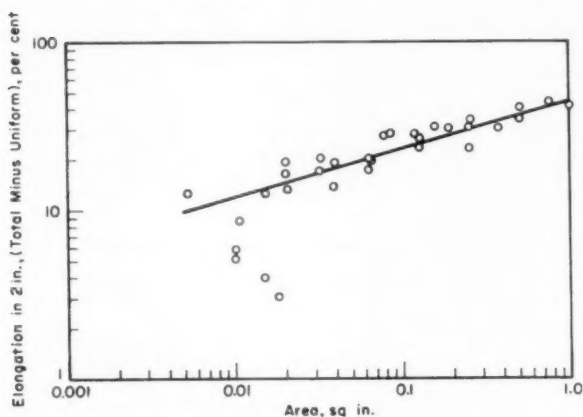


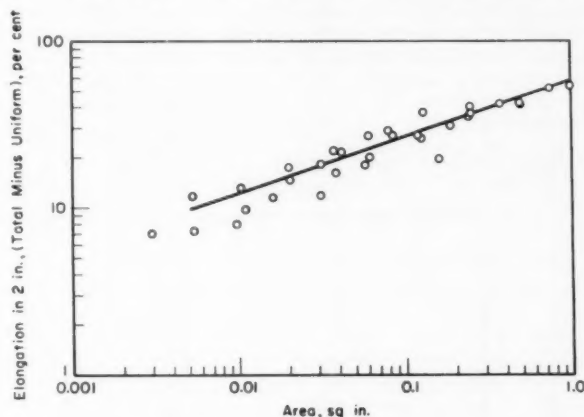
Fig. 3.—Effect of specimen area on elongation in 2 in.

approaches the uniform elongation, and for very large specimens the elongation in 2 in. approaches the zero-gage-length elongation. None of the equations approaches these limits at zero and infinite gage length, which emphasizes their empirical nature. Bauschinger's

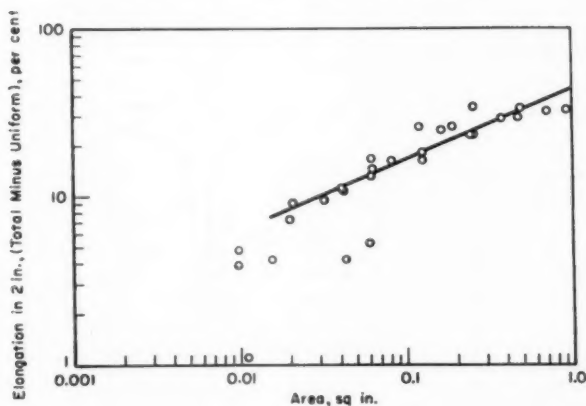
and Bertella's equations do approach a finite value at zero area, however. In Figs. 4 (a) to (d) are plotted $(El - El_u)$ versus area. The uniform elongations were determined from true stress-strain tests. It can be seen that a straight line can be drawn here also, although the



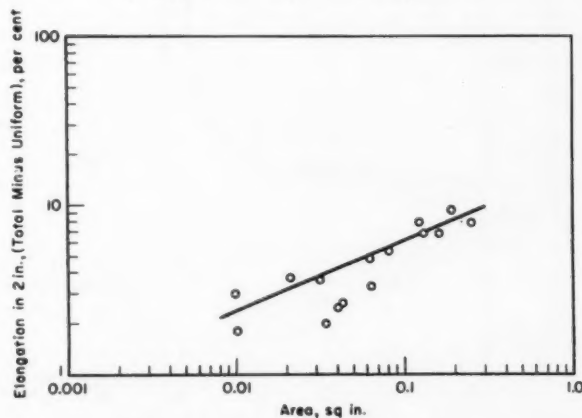
(a) Copper, hard-drawn; $El_u = 7.0$ per cent.



(b) Copper, annealed; $El_u = 26.5$ per cent.



(c) 1020 steel; $El_u = 25$ per cent.



(d) H-11 tool steel; $El_u = 4.0$ per cent.

Fig. 4.—Effect of specimen area on elongation (total minus uniform).

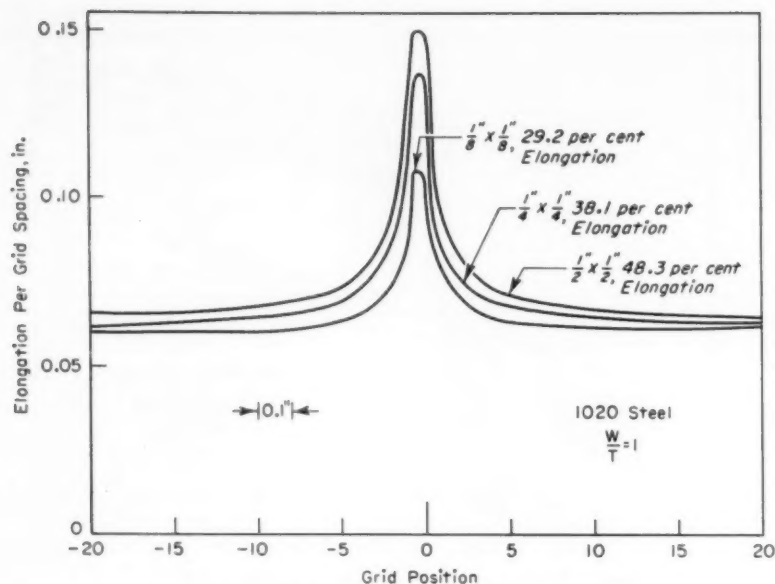


Fig. 5.—Longitudinal strain distribution in gage-length section for bars of different area.

scatter is actually greater than shown, since data points for specimens which showed an elongation less than the uniform elongation (as determined from a separate specimen) have negative values of $El - El_u$ and hence are omitted. Since an independent determination of El_u must be made, it seems that no practical advantage is offered over Templin's equation.

General Discussion

Three questions concerning the observed relationship between elongation

and area are of interest. The first is concerned with the greater significance of area, rather than width-to-thickness ratio, in determining elongation; the second with slope of the straight-line portions of the curves in Fig. 3, which is the exponent n in Templin's equation; and the third with the possibility of predicting elongation values for different size specimens.

Significance of Specimen Area

Figure 5 shows a plot of the distribution of local elongation in a specimen,

measured longitudinally over gage lengths of one grid spacing. It can readily be shown that the elongation over a 2-in. gage length can be represented on such a plot by a horizontal line drawn so that the area under it is the same as the area under the curve of local elongation. Figure 5 shows a plot of strain distribution for three bars of the same cross-sectional geometry, but different areas. The shapes of the curves are generally the same, except that as the specimen area gets larger the curve gets broader, which is an indication of the larger extent of the necked region. There is an effect of size on the maximum strain. This is caused partially by the difficulty in determining the true zero-gage-length elongation from measurements made on gage lengths of 0.05 in. minimum, and partially by a true effect of size on fracture strain (zero-gage-length elongation). Furthermore, the local strain at the extremities of the gage-length section is greater for the larger-area bar because of the closer proximity to the neck. All in all, however, the greater elongation in 2 in. (area under the curve) for the larger-area bars can be attributed to the larger extent of the necked region. Unfortunately, it is not possible to separate unambiguously the uniform-strain region from the necked region.

Figure 6 shows similar plots of local strain for three bars having the same area but different cross-sectional geometries. Within experimental accuracy, these bars have the same elongation and hence the same area under the curve. (The $\frac{1}{2}$ by $\frac{1}{2}$ -in. specimen fractured

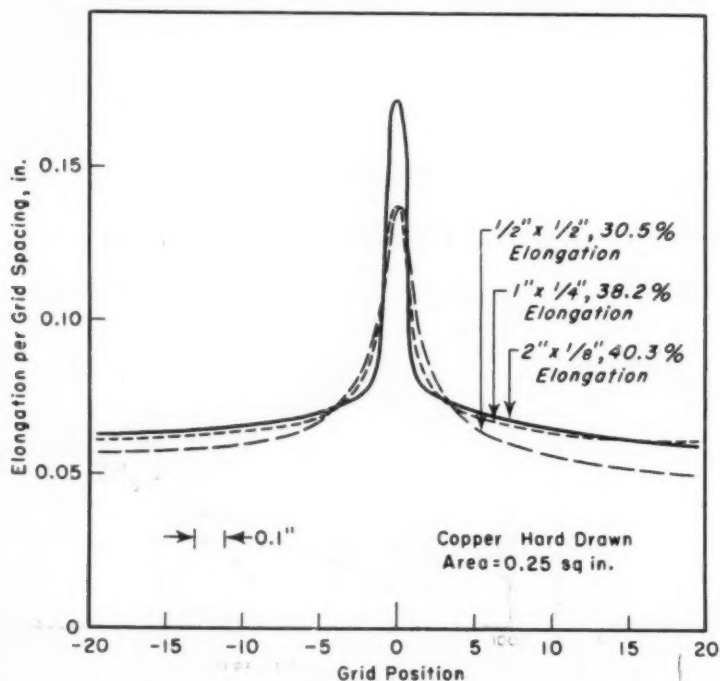


Fig. 6.—Longitudinal strain distribution in gage-length section for bars of same area but different geometry.

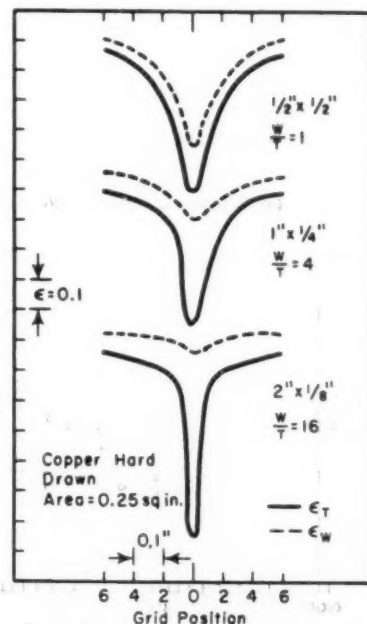


Fig. 7.—Width and thickness strain distribution in gage-length section for bars of same area but different geometry.

close to one of the shoulders, which accounts for the low elongation value of 30.5 per cent.) Notice that the shapes of the curves are quite different. At a width-to-thickness ratio, w/t , of 1, the local strain decreases uniformly with distance from the fracture. As w/t increases, there is a tendency for a more rapid decrease of strain with distance in a very narrow range in the vicinity of the fracture, with a change to a more gradual decrease at larger distances from the fracture. The height of the curve for high w/t ratios in such that at intermediate distances from the fracture it lies below the curve for a square specimen, and at large distances from the fracture it lies above, the net result being the same area under the curve.

Further insight into the shape of the curves can possibly be gained by considering the effect of width-to-thickness ratio separately on width and thickness strains. Some results are plotted in Fig. 7 where true strains have been used. The width strains were determined over one grid length (0.05 in.), whereas the thickness strains were determined over the whole thickness.

The results clearly show the differing behavior for the various w/t ratios. For a ratio of 1, the width and thickness strains are almost equal. (The hard-drawn copper is actually slightly anisotropic by virtue of having a preferred orientation arising from cold working.) As the w/t ratio increases, there is a restraint in the width direction, and the ratio of the thickness strain to the width strain increases at the fracture, so that most of the elongation at this point arises from the contribution of the thickness strain.

Significance of Exponent n in Templin's Equation

Of some importance are the slopes of the curves in Fig. 3, which are characterized by the exponent n in Templin's equation (Eq 3). The importance of this lies in the fact that it is a measure of the sensitivity of elongation values to thickness changes. It would tell, for example, whether two materials that have the same elongation value at a thickness of $\frac{1}{8}$ in. would also have the same elongation at some other thickness. One is tempted to look upon the exponent n as a material property which can be determined and tabulated. A little reflection will show the fallacy of such an approach.

Since the length along the specimen occupied by the neck is proportional to the specimen cross-sectional area, the elongation in 2 in. would be simply the maximum uniform strain for a bar of infinitely small area (assuming homogeneous deformation until maximum load). Similarly, for a bar of infinite cross-sectional area, the elongation in 2 in. approaches the zero-gage-length elonga-

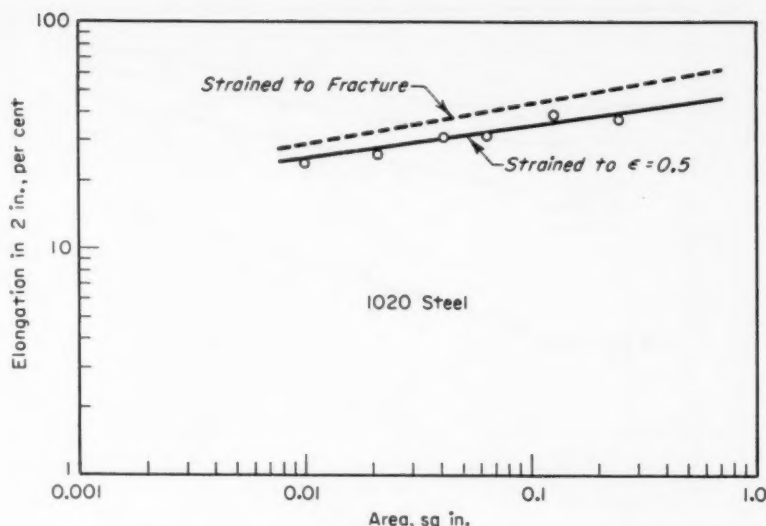


Fig. 8.—Variation of elongation in 2 in. with specimen area.

tion, which can be calculated from the reduction of area or fracture strain. The zero- and infinite-gage-length elongations therefore define the upper and lower limits respectively of a log-log plot of elongation in 2 in. versus specimen area.

In order to show the importance of zero-gage-length elongation in controlling the elongation-area curve, this maximum strain was reduced, maintaining the uniform strain constant. This was done by loading in tension a series of AISI 1020 steel bars of different areas to a true strain at the neck of 0.5. The average strain in 2 in. was measured and is plotted in Fig. 8 together with the line for the bars loaded to fracture. It can be seen that the slope is reduced by reducing the maximum strain to 0.5. This can more strikingly be visualized by considering bars which might fracture before necking has started. In such a case, the elongation would be independent of gage length and specimen area, and the data would appear on a plot such as Fig. 8 as a horizontal line with a slope of zero.

Although the fracture and uniform strain define the upper and lower limits of elongation, the actual data would probably form an S-curve. Over the range of areas of practical interest a straight line can probably approximate the data. To a first approximation the slope of this line, the constant n in Tem-

plin's equation, would be proportional to the difference between the logarithms of the zero- and infinite-gage-length elongations (fracture and uniform strains) and, hence, to the logarithm of the ratio of these elongations. This quantity for the various materials is listed in Table II, together with the slopes n from Figs. 3 and 8. The zero- and infinite-gage-length elongations were obtained from the reduction of area at fracture and the strain at maximum load for 0.357 in. round specimens (Table I), except for the H-11 steel, for which the zero-gage-length elongation was calculated from the sum of the width and thickness strains of a $\frac{1}{2}$ by $\frac{1}{8}$ -in. specimen.

The results do show a rough correlation between the logarithm of the ratio of these elongations and the slope. There are many assumptions made in this analysis which must be considered. First, it has been assumed that the slope of the actual S-curve is proportional to the difference between the maximum and minimum values. Furthermore, it is assumed that the zero- and infinite-gage-length elongations are independent of specimen dimensions. In addition, there are experimental difficulties in determining the zero- and infinite-gage-length elongations. A small change in the infinite-gage-length elongation can cause an appreciable change in the logarithm of the ratio.

TABLE II.—ZERO- AND INFINITE-GAGE-LENGTH ELONGATIONS AND TEMPLIN'S EXPONENT FOR MATERIALS TESTED.

Material	Zero-Gage- Length Elongation, El_0 , per cent	Infinite-Gage- Length Elongation, El_∞ , per cent	El_0/El_∞	$\log El_0/El_\infty$	Templin's Exponent, n
AISI 1020 steel strained to 0.5.....	65	25	2.6	0.41	0.14
AISI 1020 steel, fractured.....	170	25	6.8	0.83	0.18
Copper, annealed.....	238	26.5	9.0	0.95	0.16
Copper, hard-drawn.....	225	7.0	32.0	1.51	0.23
H-11 tool steel.....	63	4.0	15.7	1.20	0.30

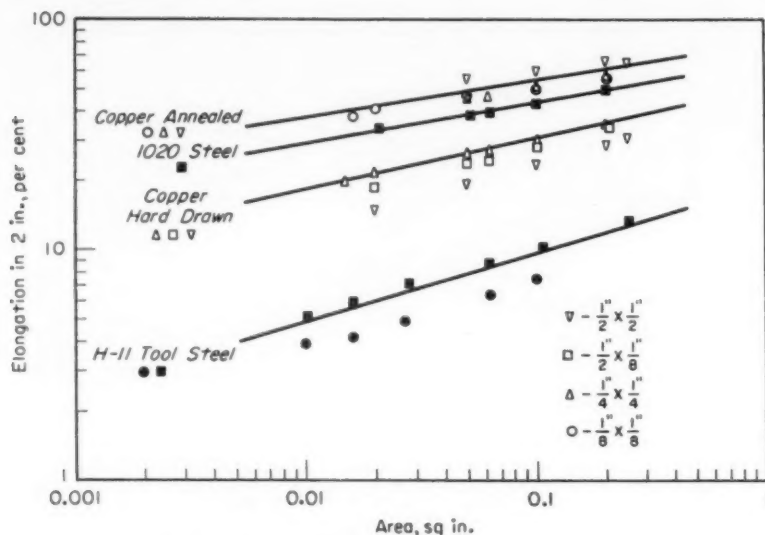


Fig. 9.—Calculated variation of elongation in 2 in. with specimen area.

In spite of the crudeness of the analysis, it does point out some useful trends. From these considerations, it can be seen that the exponent n in Templin's equation is not a general material property which can be tabulated but depends rather on the ductility of the specific lot of material being tested. For two different materials with the same uniform strain, the one having the higher fracture strain would have the greater value of the exponent n . Similarly, for a constant fracture strain, the lower the uniform strain the higher the value of this exponent. Unfortunately, the high-strength sheet materials of current interest do have a low value of uniform strain with moderate fracture strains, so their elongation values are quite sensitive to variations in thickness (area).

Prediction of Per Cent Elongation

In many cases it would be desirable to be able to predict the elongation for a specimen of arbitrary size. Lacking complete data for many specimens which would allow an interpolation to be made, there is a method which suggests itself. This is based on the concept that a constant elongation is obtained if L/\sqrt{A} is maintained constant as suggested by Bauschinger's equation (Eq 1). This concept is inherent in maintaining a gage-length-to-diameter ratio of 4 for round tension specimens and in the practice used abroad of defining gage length as a constant multiple of the square root of the area. Malmberg (6) found this to be valid for round bars but not for rectangular bars. The results of this investigation support

Malmberg. Nevertheless, under some conditions it is a good approximation for rectangular bars. If it is valid, then at a constant value of elongation:

$$\frac{L_1}{\sqrt{A_1}} = \frac{L_2}{\sqrt{A_2}}$$

where L and A are the gage lengths and areas of two different bars, 1 and 2. To determine the elongation in length L_2 on a bar with an area A_2 from measurements on a bar with area A_1 , simply measure the elongation on bar 1 over a gage length $L_1 = L_2\sqrt{A_1/A_2}$. From this relation, the elongation in a fixed gage length for a bar of any area can be calculated from measurements over different gage lengths on one bar.

Some results using this method have been calculated for several size bars of the various materials and are plotted in Fig. 9 with the experimentally determined results from Fig. 3. In some cases the points do not lie on the experimentally determined curve, since the standard 2-in. elongation for the bar used lies off the curve. In general the results are good, and the slopes of the experimental and calculated curves are the same. Deviations are noted when the elongation must be measured over such a long gage length that either a second necked region or end restraints are encountered.

In a practical sense, this principle could be applied to standard $\frac{1}{2}$ -in. wide specimens. Suppose, for example, one had available and knew the properties of $\frac{1}{2}$ -in. sheet. What elongation would be expected in sheet 0.080 in. thick? From the above relation, one can determine that the elongation measured on

$L = 2\sqrt{0.125/0.080} = 2.5$ in. of the $\frac{1}{2}$ -in. sheet is the same as the elongation in 2 in. of 0.080 in. sheet. Accurate values should be obtained if the areas do not differ appreciably.

Summary

A study has been made of the effect of specimen width and thickness on the elongation in 2 in. as determined in a sheet tension test. Hard-drawn copper, annealed copper, AISI 1020 steel, and H-11 tool steel were studied.

The elongation in 2 in. is found to vary approximately linearly with the specimen area on a log-log plot, showing agreement with Templin's equation, $El = CA^n$. The reason for the greater dependence of elongation on specimen area, rather than on the ratio of width to thickness, can be seen from a study of the local width, thickness, and longitudinal strains.

The sensitivity of elongation to specimen area or thickness, as measured by the exponent n in Templin's equation, is dependent on the fracture strain as well as the uniform strain, and hence varies from heat to heat of material. This exponent has been related to the logarithm of the ratio of the zero-gage-length (fracture strain) to infinite-gage-length (uniform strain) elongations.

If L/\sqrt{A} is maintained constant, the elongation will be approximately constant. Using this relation, it is possible to estimate the elongation for any size bar from measurements made on one bar.

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Technical Note

Size of Irregular Particles

By R. R. IRANI¹ and D. P. AMES¹

THE SIZE of a particle, M_0 , is that representative dimension which best describes its degree of subdivision. The diameter of a particle, d_i is any straight line passing through the center of the particle and terminated at the particle boundary (1).²

For a spherical particle, diameters in all directions are equal; hence, diameter and size become synonymous. For an irregularly shaped particle, a large number (approaching infinity) of nonequivalent diameters satisfying the above definition exist. The distribution of these diameters is continuous between upper and lower limits. Therefore, the size of an irregular particle is a statistical average of some type of all of these diameters. Consequently, the size of a given particle depends on the specific averaging method.

With any particle-size measurement there coexists an inherent type of diameter-averaging. For example, provided no preferred orientation is encountered, the size obtained from microscopic area measurements (2) is the geometric average of the diameters, M_1 ,

$$M_1 = \frac{d_m}{n} \prod_{d_i = d_s} [d_i]^{1/n}$$

where:

n = the number of diameters, and d_s and d_m = the smallest and largest particle diameters, respectively.

On the other hand, unidirectional microscopic length measurements (2, 3) give the arithmetic average of the diameters, M_2 :

$$M_2 = \frac{1}{n} \sum_{d_i = d_s}^{d_m} d_i$$

When size is obtained from settling velocities, the force opposing sedimentation is proportional to M_1 .

According to the above, the numerical values of the commonly employed par-

TABLE I.—EFFECT OF PARTICLE DIAMETER RATIO ON PARTICLE SIZE.

Ratio of Maximum to Minimum Diameter	Number of Diameters Measured (averaged)	Per Cent Deviation Between Sizes From Geometric and Arithmetic Averages ^(a,b)
2	2	6
	4	3
	6	3
	10	2
	100	2
3	2	13
	4	8
	6	6
	10	5
	100	4
4	2	20
	4	12
	6	10
	10	8
	100	6
10	2	43
	4	27
	6	22
	10	18
	100	11

(a) Assuming equal diameter intervals.

(b) $100[1 - (M_1/M_2)]$.

ticle sizes lie between the arithmetic and the geometric averages of the diameters. Table I demonstrates that these averages approach one another as the number of averaged diameters increases.

Even though only one diameter per particle is measured in unidirectional microscopy, many similar particles are randomly positioned so that, in effect, several diameters are considered. Table I shows that a larger number of similar particles must be measured for highly irregular shapes. Furthermore, particle-size distributions measured by reliable methods must agree within experimental error provided d_m/d_s is 4 or less and the distributions are expressed on an equivalent basis; for example, weight-size. Several studies have verified this conclusion (3-9) in that the shape factors are not required for $d_m/d_s \leq 4$.

In measuring particle-size distributions microscopically, the total number of particles considered should not be less than the number of size intervals

times the number of averaged diameters at which the arithmetic and geometric averages approach one another. For example, if the particles of a powder have $d_m/d_s = 3$, and 8 size intervals are required, 80 particles or more should be counted and sized. On the other hand, if $d_m/d_s \geq 4$, several hundred particles should be considered.

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² The boldface numbers in parentheses refer to the list of references appended to this paper.

For a Unified Grain-Size Standard

By L. L. WYMAN¹ and R. E. PENROD²

The newest ASTM grain-size standard has come of age. The sponsoring committee hopes to see it replace the four older methods for estimating grain size of metals.

AT THE TIME of the publication of the 1955 Book of ASTM Standards, there appeared a new proposal, Tentative Methods for Estimating the Average Grain Size of Metals (E 112-55 T).³ This tentative was the result of many years of intensive efforts by a number of prominent metallurgists from laboratories representing a wide array of metals interests. The ultimate objective, as set forth in an article⁴ describing this work, was to arrive eventually at but one set of procedures that would embrace all metallurgical interests in grain-size evaluation rather than to continue use of the four older methods,⁵ as well as their inaccuracies.

Since 1955, Subcommittee VIII of Committee E-4 on Metallography has continued work on this proposal in two areas. First, the desired array of comparison charts was completed by obtaining the desired material, structures, photomicrographs, and standard size array for Plate II, Twinned Grains, Flat Etch (see Fig. 1). Then the contents of the original proposal were improved so that it would cover all pertinent aspects of grain-size evaluation as determined by Society requirements.

The task group assigned to the preparation of Plate II studied a wide variety of materials and encountered many disappointments in its endeavor to obtain a material with a microstructure suitable for this standard chart. Most of the commercially available

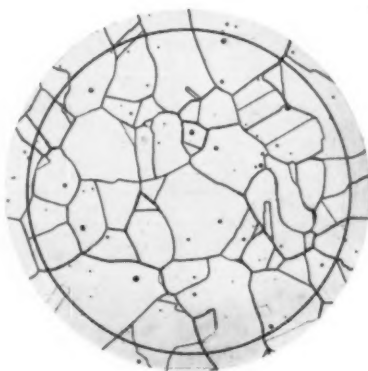


Fig. 1.—Example of Twin Grains (Flat Etch) from Plate II. Grain Size No. 3 at 100 \times (reduced one third in reproduction).

products, and even some special alloys, revealed too much or too little twinning, or they had too many inclusions, or combinations of all of these.

In 1959, a material was especially prepared for this work, and its structure at several levels of grain size was approved for use in making up the standards. Unfortunately, alloys of this type have very poor etching characteristics for delineating all of the grain boundaries, and it became necessary for the task group to conduct a number of interlaboratory tests in order to obtain complete agreement on the exact locations of the grain boundaries before the standardizing operations could be undertaken. The results from eight laboratories concerned with both ferrous and non-ferrous materials gave most surprisingly close agreement. The completed Plate II is now available.

The text of the original proposal has been appreciably enhanced by the complete recalculation of the master tables showing grain-size relationships as well as the enlargement of the "micro" tables to ASTM grain size No. 14, which appears to be adequately beyond present requirements. In calculating the new tables, exact values were used throughout, thus eliminating errors which were introduced in earlier tables by rounding off intermediate

values during the calculations. Because of the enhanced accuracy of the present method and tables, Committee E-4 has taken the firm stand that "rounding off" means should not be applicable to method E 112 procedures. However, the use of such means to simplify grain-size stipulations in materials specifications is fully within the prerogatives of a product specifying committee.

In order further to enhance the use of Method E 112, recommendations concerning means of operator self-checking have been added, and a table showing the reference charts preferred for different alloy types has been included. Also, the necessity for using prescribed procedures for developing the austenitic grain size in steels does, in a sense, make these treatments a part of the specimen preparation for grain-size evaluation; thus these procedures have been included as an appendix to method E 112.

Following the foregoing improvements, which appeared in Method E 112 - 58 T,⁶ and as a result of the much more extensive use of this proposal since then, the convenience of the tables has been further increased by the inclusion of a column of intercept distances for the macro-grain sizes. Also, it has been found that there have been many instances in which individuals have rather thoughtlessly averaged grain-size results arithmetically. This is totally in error, because the ASTM grain sizes progress geometrically, not arithmetically. In order to remove any misapprehension on this score, a paragraph has been included which outlines means of averaging.

Since the appearance of the 1958 version of these methods, the use of Method E 112 has grown rapidly in the aluminum industry; a number of the new and recently revised ASTM specifications for nickel and nickel-base alloys now refer to these methods; and a number of steel laboratories have already worked out conversion curves for their products in order to correct the erroneous results obtained from Classification E 19 to the correct grain-size values obtained from Method E 112.

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³ 1955 Book of ASTM Standards, Part 2, p. 1435.

⁴ L. L. Wyman, "The New ASTM Grain-Size Methods," ASTM BULLETIN, No. 215, July, 1956, p. 59.

⁵ Standard Classification of Austenite Grain Size in Steels (E 19-46); Tentative Methods for Estimating the Average Grain Size of Wrought Copper and Copper-Base Alloys (E 79-49 T); Standard Methods for Estimating the Average Ferrite Grain Size of Low-Carbon Steel (E 89-52); Tentative Methods for Estimating the Average Grain Size of Nonferrous Metals, Other Than Copper, and Their Alloys (E 91-51 T).

⁶ 1958 Book of ASTM Standards, Part 3, p. 506.

For the copper and brass interests it may be said that all of the traditionally used Method E 79 is contained in Method E 112 in greatly improved and expanded form.

As an interesting side light on two facets of the subject of grain-size evaluation, the 1956 ASTM BULLETIN article⁴ called attention to the fact that this was basically a problem in geometry, which was not material-dependent. Also, the gross errors in some of the older methods were cited.

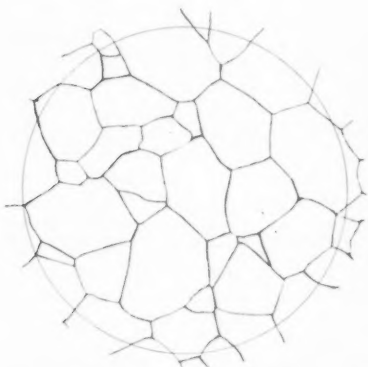


Fig. 2.—Example of Untwinned Grains (Flat Etch) from Plate I. Grain Size No. 3 at 100 \times (reduced one third in reproduction).

To emphasize the validity of these points, a paper presented at the recent Symposium on Quantitative Metallography not only shows that a properly programmed computer of suitable type can measure and arrive at a grain-size distribution from a micrograph, but, when said micrograph was ASTM grain size No. 5½ from Plate I of method E 112-60 T, the computer also verified the average grain size to be 5½.

At the present time, it is the firm conviction of the members of Committee E-4 that Method E 112 will require no further changes in the foreseeable future; thus it should be immediately adopted as an ASTM standard. The necessary steps to accomplish this are now in progress. This action is particularly advisable because of the confusion that exists, both in this country and abroad, because of the present appearance in Society recommendations of five methods of doing the same metallographic operation.

To rectify this situation, the chairman of Committee E-4 has been instructed by the committee to ask of each product committee (a) that it adopt Method E 112 for all grain-size evaluation necessary for its products, and (b) that it request Committee E-4 to withdraw the older methods applicable to the committee's products. To this end, it may be reported that several product committees have already taken some action in this direction—Committee B-2 on Non-ferrous Metals and

alloys is now using method E 112; members of Committee B-7 on Light Metals and Alloys at a recent meeting advised of its widespread use in their laboratories, and the committee plans to take official action at the June meeting; Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys has taken official action

in favor of the above actions; and several subcommittees of Committee A-1 on Steel have also acted favorably. Indeed, it would in many respects be to the great advantage of industry and to the Society to have these recommendations adopted and the present confusion resolved before publication of the 1961 Book of ASTM Standards.

Jost Amman on Commerce



Harvard Graduate School of Business Administration

This allegorical representation of commerce, based on the business scene in Sixteenth Century Germany, was conceived by Johann Neudörfer and engraved on six woodblocks by Jost Amman (1539-1591). It was printed at Augsburg in 1622. One of the most comprehensive early portrayals of the business scene, the print carries the coats of arms of the leading commercial cities of Europe, arranged by the months of the year when fairs took place. Beneath these are Mercury and Fortune, with scales symbolizing the balance sheet. A series of vignettes delineates the business establishment of a merchant prince, and various figures stand for the qualities and knowledge that make for success in business: a sense of duty, integrity, taciturnity, a knowledge of language, and freedom of trade. Verses by Casper Brinner, Neudörfer's pupil, explain double-entry bookkeeping. Other verses interpret the various aspects of business activity. The print now hangs at Baker Library, Harvard Graduate School of Business Administration.

Text by Professor Derek J. de Solla Price, Yale University. Copyright; text and photographs reproduced by permission of Professor Price and Arthur D. Little, Inc.

The Role of Transmission Electron Microscopy in Fundamental Fatigue Studies¹

By H. G. F. WILSDORF²

IN THE PAST, the electron microscope has been used to study surface phenomena on fatigued metals. The nature of slip markings, in particular extrusions and intrusions, has been investigated successfully. Recently, electron microscopy has been used to explore the internal structural changes in fatigued metals. This is being done by observing single dislocations and their patterns directly in thin foils which have been produced by electrolytic cutting and polishing from the fatigued test specimen.

It should be pointed out that the contrast mechanism used for dislocation studies is entirely different from that which produces the contrast in replica work. For the latter, contrast is governed by the mass thickness effect according to

$$I_s \approx I_0 e^{-\sigma t N}$$

where:

I_0 and I_s are the electron current before and after transmission of the amorphous replica,
 t is the thickness,
 σ is the total scattering cross-section of the atoms, and
 N is the number of atoms per unit volume.

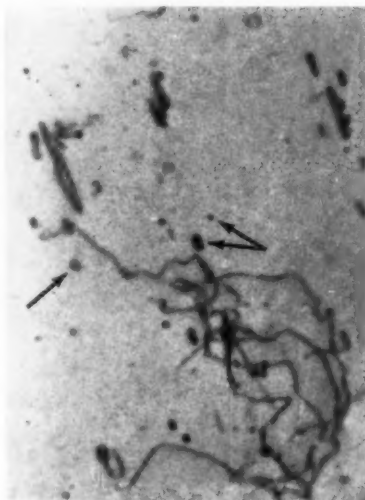
For studying dislocations the technique of *diffraction contrast* is being used. Here, the specimen has to be suitably oriented so as nearly to satisfy Bragg's law

$$2d \sin \theta = n\lambda$$

where:

d is the distance between reflecting lattice planes,
 θ is Bragg's angle,
 λ is the wavelength, and
 n is an integer.

It is important to remember that Bragg's condition has to be nearly satisfied, but *not quite*, since the distortion around a dislocation provides enough lattice rotation to diffract electrons ac-



The specimen, approximately 3000 Å thick, was produced by an electrolytic polishing technique from a tensile specimen 1 mm thick. Arrows point to small prismatic dislocation loops. ($\times 40,000$)

Fig. 1.—Electron micrograph showing single dislocations produced during deformation of aluminum single crystal (strain = 0.05).

cording to the above formula. Further, one more condition has to be fulfilled, namely, the Burgers vector of the dislocation has to be perpendicular, or has to have a perpendicular component, with respect to the reflecting lattice planes.

The information that can be obtained under favorable conditions can be explained with the help of an electron micrograph. The dark lines in Fig. 1 represent single dislocations which have been produced during the deformation of an aluminum single crystal. The arrangement of the dislocations as well as their shape allow valuable conclusions to be drawn regarding their propagation, multiplication, and the nature of obstacles.

The reason why results obtained by diffraction electron microscopy are of importance to fatigue studies is evident when one considers the close relationship between work hardening in unidirectional strain and fatigue. In addition, the effect of point defects on fatigue

behavior may be directly observed in favorable cases. Point defects, for example vacancies, often are generated when dislocations move through the lattice. Reaching a given supersaturation, vacancies can condense into a layer, thereby producing a prismatic dislocation loop. These loops may be circular, as shown by the arrows in Fig. 1, and vary in diameter between 50 and 1000 Å. Other prismatic loops observed are long and narrow and are thought to have been caused by vacancies through a combined glide and climb mechanism.

Recent investigations have indicated that vacancies affect, indeed, the behavior of dislocations in fatigued metals. With increasing cycles the number of prismatic loops has been found to increase, which can be taken as evidence for the generation of point defects. It is the subject of present research to correlate these experimental findings with the theory of crack formation in fatigued metals. In particular, the irregular shapes of dislocations, often arranged in tangles, are not accounted for by the theory, and it can be expected that the results obtained by this new technique will strongly influence our thinking on the fatigue mechanism. Of course, diffraction electron microscopy should be used in conjunction with conventional research methods such as $S-N$ diagrams, recording of hysteresis loops, and metallographic surface observations.

Catalog of American Standards Published

THE 1961 catalog of American Standards containing price lists and an index of the standards as well as recommendations of the International Organization for Standardization and the International Electrotechnical Commission has been published by the ASA. A 72-page brochure, available without charge, it lists nearly 2000 American Standards in 22 categories from acoustics, vibration, mechanical shock and sound recording, to the textile and wood industries. Copies may be obtained by writing ASA headquarters.

¹This is a summary of a talk given at a meeting of Committee E-9 on Fatigue in Atlantic City during the 64th Annual Meeting of the Society.

²Technical Director, Solid-State Science Div., The Franklin Institute Laboratories, Philadelphia, Pa.

Fifty Years of ASTM Membership¹

By Rear Admiral M. J. Lawrence²

PROBABLY THE FIRST specification ever written, and significantly enough it dealt with materials for shipbuilding, can be found in the Book of Genesis, chapter 6, verse 14: "Make thee an ark of gopher wood; rooms shalt thou make in the ark, and shalt pitch it within and without with pitch." We in today's Navy find that materials specifications are considerably more complicated than these rather simply worded requirements stated in Noah's time. The creation of new specifications for today's rapidly growing lists of materials to meet modern design purposes requires comparison test methods and procedures of highest reliability and reproducibility to prove the worth of these materials. Such requirements for meaningful tests places a great and continuing task before the entire composition of this Society. It is therefore my pleasure and privilege to participate in this event, which commemorates 50 or more years of continuous membership in ASTM of nearly 30 groups represented here today. It is my particular pleasure to represent the Bureau of Ships on the marking of its 50th year of cooperative effort with ASTM in the fields of materials specifications and test methods.

Our Changing Defense Needs

These 50 years in which the Navy has been a member of ASTM have seen a fantastic change in our Navy as well as in every element of our armed forces, in our scientific and in our industrial efforts. In fact, we can all justifiably claim to have participated in the

greatest explosion of materials technology since time began. However, in spite of what is happening today, we can look back and see that a great deal was being accomplished 50 years ago. In 1911, which was the first year of Bureau of Ships participation, ASTM was publishing specifications for structural steel for ships. Shortly thereafter, more materials standards of ASTM became cross-referenced and identifiable with Bureau of Ships' and other Navy bureaus' specifications. Various basic test methods of ASTM became our test methods too. It is very likely that the build-up of the U. S. Fleet in World War I would never have been accomplished so smoothly and efficiently had it not been for the high quality of specifications and test methods made available by this great Society. A big job was done, and done well, because of a U. S. industry that performed to the standards set largely by ASTM.

In the 23 years between the end of World War I and the United States' entry into World War II, a great change took place in the Navy and in the Army. New tactics, new plans, and new operations were developed, tested, revamped, and redeveloped. New ships, tanks, ordnance of all types, aircraft, and electronics changed the entire complexion of our defense arms. Along with developments in tactics and doctrines, and with equal emphasis and importance, came developments in materials to support these new theories and to supply the equipment to build a defense and to make an offense. Technical services and bureaus of the Army and Navy became known also as material services and bureaus because, in fact, this is exactly what they were. Navy and Army officers became educated, experi-



REAR ADMIRAL M. J. LAWRENCE

enced, and thoroughly knowledgeable in material development, material specifications, and material test methods and procedures. Likewise, during World War II the rosters of the armed services were swelled with thousands of people direct from industrial life who brought with them hundreds of thousands of man years of outstanding materials experience and knowledge. With this great ability, in and out of the Services, the United States was able to build the greatest machine of war ever known, and by this means was able to beat the enemy on all fronts.

It would be natural to suppose that with the cessation of hostilities in 1945 the abilities that were developed during the war would vanish. Surprisingly enough, although the great majority of people from industry did return to their peacetime work, the mold had been well made. The technical bureaus and services were truly in business as materials organizations.

Since the clouds of war never really cleared away, it was obvious that continued emphasis must be put into materials and design improvements to modernize our armed services and make them ready to move and to fight under an entirely new set of rules. New concepts of military organization arose and greatly affected the research and development, design and engineering, and test and evaluation work of the Army, Navy, and Air Force. The Defense Standardization Act (P.L. 436) and other laws demanded standardization and simplification of military specifications and standards and, furthermore, greatly encouraged the use of the specifications and standards of recognized industrial and technical societies of which one, of course, is ASTM. Certainly, to the

¹ Address presented at the Awards Luncheon, June 28, 1961, 64th Annual Meeting of the Society, Atlantic City, N. J.

² Assistant Chief of the Bureau of Ships for Technical Logistics, Washington, D. C.

Bureau of Ships working with industry and technical groups was not new—as witness the fact that the Bureau has been and is represented to some degree on approximately 500 technical committees and subcommittees, about 200 of which belong to ASTM.

The Role of ASTM Standards

At this point, I should like to picture to you the great part that ASTM has played in military specifications and standards work. The Bureau of Ships is responsible for the preparation of 4700 specifications, standards, and handbooks, all of which we will refer to as documents. The Navy as a whole is responsible for the preparation of 12,000 documents. In all, it uses a total of 19,000 military documents, some 7000 of which are prepared by our sister services. The entire defense establishment uses 30,000 military specifications, standards, and handbooks. The interesting facts contained in all of these figures is that many of these military documents are the same as or comparable to those of ASTM, and there is hardly a document in the entire group of 30,000 which does not either directly or indirectly refer to one or more ASTM standards. In the specific area of textiles and cordage, about 95 per cent of our test methods are the same as or comparable to ASTM methods. Also in a great many of our fully coordinated Federal Test Method Standards, the methods contained therein are quoted directly from ASTM or refer directly to an ASTM standard without reprinting it.

Think what would happen if by some action all ASTM standards were suddenly destroyed! The whole of industry would grind itself into utter chaos, because it would be impossible to conduct any kind of business as we know it today in this country without the use of those documents. Raw materials could not be made or refined because many essential controls would be missing. Semi-finished materials, subassemblies, components, etc., could not be made and transferred from one manufacturer to another because of the lack of standards to measure quality or performance. Evaluation and testing of completed or finished materials and products, which might have been on hand, would be close to impossible, because almost every facet of this work depends, directly or indirectly, on one or more ASTM standards. Without them, no one could do business.

I do not expect that anything as catastrophic as my hypothetical case will ever happen. Conversely, I do expect that the work of ASTM will continue and will forge ahead to meet the demands of material developments now and in the future.

Materials—the Key to Defense

I believe we realize and accept that wars are fought and won with materials just as much as they are with men. In this age of nuclear submarines, missiles, rockets, and orbital vehicles, it may well be that materials will surpass man in importance and usefulness in making war. What we do in a scientific and military way in the future will depend entirely on our ability to develop and perfect new materials, and it is quite certain that most of these new materials will bear little resemblance to what we have used in the past and are using now.

The Navy needs materials and equipments for its challenging future and they may be simply described by words such as faster, deeper, quieter, lighter, stronger, and more dependable. Our search is certainly in the direction of achieving these qualities.

Because of obvious requirements to go deeper and deeper into the ocean, we are in an intensive development program directed toward nearly doubling the yield strength of our ferritic-alloy submarine hull material, which is known as HY-80 steel. In other words, we are looking to a yield strength of 150,000 psi in place of our still-new 80,000 psi materials. Our real problem is not metallurgy so much, because our industry already knows how to make the material. Our big search is to learn fabrication techniques that are compatible with such high-strength ferritic alloys and which can be economically performed. We must know when we have the right material—material whose weight, strength, and cost are consistent with our needs.

Simultaneously, we are carefully examining the potentialities of high-nickel alloys which are expected to produce greater than 150,000 psi yield strengths and which, we hope, will provide improved welding and fabricability characteristics.

The vast preponderance of the ocean floor is inaccessible to us now, but with the necessity to go deeper, and with an insatiable desire to explore and possibly to exploit those now restricted depths, we hope to achieve a more favorable weight-to-volume ratio and to obtain unheard-of yield strengths of submarine and submersible hull materials.

It may be surprising to learn that reinforced plastics are actively under consideration as deep-diving hull materials. Recent laboratory scale models have exhibited collapse strengths much greater than our current submarine hull materials. Here again, many unanswered questions concerning fabricability and repairability will require much continued effort to unravel.

The plastics field is yet in its infancy, and many fascinating things are in the

offing and are not too far away. Our boron-polymer work is expanding rapidly and offers excellent prospects of producing heat-stability characteristics some 200 C above today's silicones and fluorocarbon compounds. Boron polymers will play a major role in development of space-age hydraulic fluids, elastomers, and dielectrics.

Other plastics are being developed by industry-military joint effort to sound-deaden hull and machinery spaces, to provide noise-reducing turbine and gear lubricants, and to provide greater protection and safety.

New developments in materials, whatever they may be, will force new developments in test and evaluation methods to determine their qualifications, safety, durability, performance, and acceptance characteristics. New standards to measure and assess these characteristics must be produced. Today we badly need nondestructive test methods to determine the soundness of silver brazed joints and many other items of hardware. Tremendous effort and much tedious work is ahead of U. S. industry and the armed forces to discover, to improve, and to determine the effective reproducibility, repeatability, and the true significance of test and evaluation methods and procedures and how they will relate characteristics of qualities found in basic tests to the true application and performance of materials under consideration. In ASTM you have the knowledge, the experience, the capacity, and the coordinated organization of talents to help meet the challenge and to produce the results. I feel that I cannot stress too forcefully the early need for greater joint military-industry cooperative efforts in bridging the gap between the basic material and its true performance in integrating materials and their products into the operational weapons systems which are so vitally important to our nation's defense. Speaking for the Bureau of Ships, and I am sure the same applies to the other Navy bureaus and their counterparts in the Army and the Air Force, we stand ready to work with ASTM and with industry to accomplish the job before us.

In conclusion, and on behalf of the chief of the Bureau of Ships and the personnel in the Bureau, I wish to congratulate the ASTM on its 63 years of very successful leadership in the field of materials specifications and testing and to extend warmest best wishes to those member groups which, like the Bureau of Ships, have now passed the half-century milestone of cooperative effort in this great organization. Our sincere wish is that the future will provide even greater accomplishments for the American Society for Testing Materials and its many participants.

Society Affairs

R. J. Painter Honored for Service to ASTM

THIRTY YEARS OF devoted service to ASTM were capped at the President's Luncheon during the 64th Annual Meeting when Robert J. Painter received the announcement by President Bates that the Board of Directors had conferred on him the title of Executive Secretary Emeritus.

Tangible evidence of the unique honor was an embellished, framed certificate presented to Mr. Painter by President Bates. And evidence of the heartfelt approval of the hundreds present was the spontaneous, standing ovation that followed the announcement.

After a courageous fight against osteoarthritis, involving hip operations in March, 1958, and again in July, 1959, and during which periods for many months he made valiant efforts to carry on the work of the office of executive secretary, even from his hospital room, Mr. Painter and the Board of Directors were finally forced to concede that the effort was too great a drain on Mr. Painter's strength. In October, 1960, Mr. Painter became consultant to the new executive secretary, T. A. Marshall, Jr.

The beginning of a long and fruitful association was announced inauspiciously enough by the following two-paragraph story in the March, 1931, ASTM BULLETIN:

We are pleased to announce the addition to the Society's staff of Mr. Robert J. Painter, a graduate of Rensselaer Polytechnic Institute, class of 1928. Subsequent to his graduation, Mr. Painter spent a year as an instructor at Rensselaer, followed by a year and a half in the special engineering department of the Bethlehem Steel Co. The growth of Society activities within the past year or so has made necessary this addition of a technically trained assistant.

Mr. Painter will be engaged specifically with the publicity and promotional work of the Society, including publication of the ASTM BULLETIN. He will also assist the Secretary-Treasurer in the management of the Exhibit of Testing Apparatus and Machines to be held in conjunction with the annual meeting this year.



R. J. PAINTER (LEFT) RECEIVES CERTIFICATE FROM PRESIDENT BATES

The certificate reads: "With sincere appreciation and in recognition of the distinguished service of Robert J. Painter to the American Society for Testing Materials, and of his outstanding and effective leadership as its Executive Secretary, the Board of Directors in behalf of the Society conveys its grateful thanks and high esteem and confers on him the title of Executive Secretary Emeritus."

That exhibit, held at the 34th Annual Meeting, in Chicago, was the first to be held by the Society. It was also the first major Staff responsibility for Mr. Painter, and one that he retained for many years to come. Something of a shutterbug himself, he later was instrumental in adding the highly successful photographic exhibit.

The bare bones of the 30 intervening years are that Mr. Painter was made assistant secretary in 1946 and executive secretary and treasurer in 1952. In those 30 years the membership of the Society has more than doubled, the Book of Standards has grown from two to

eleven parts, and the Society's annual operating budget has mushroomed from about \$140,000 to nearly \$1.5 million.

Long conscious of the need to promote ASTM at the grassroots, Mr. Painter has always been a firm believer in carrying the message personally to all parts of the nation. He was a very effective spokesman for the Society. His many trips, usually in the company of the Society president, laid the groundwork for the establishment of many of the ASTM Districts, particularly in the West, the Northwest, and the Southwest. It is largely through his effort that the Districts have spread westward to the

Pacific Coast and have become the great benefit that they are to Society operations.

Mr. Painter was also secretary of the Membership Committee for some 20 years, during which time he was responsible for membership promotion. It was during this period that he became responsible to his predecessor, C. L. Warwick, for developing and building the sustaining membership of the Society. He also directed the Staff work in connection with the establishment of the Society's Award of Merit program.

During World War II, a National Emergency Steel Specifications project was sponsored by ASTM, SAE, and AISI to develop standards that would be the only ones used in an effort to concentrate production on a limited number of grades of steel and steel products. The work of the various committees, which were largely organized through Mr. Painter's efforts, as assistant to Mr. Warwick, who was then in Washington, eventually resulted in production directives from the War Production Board.

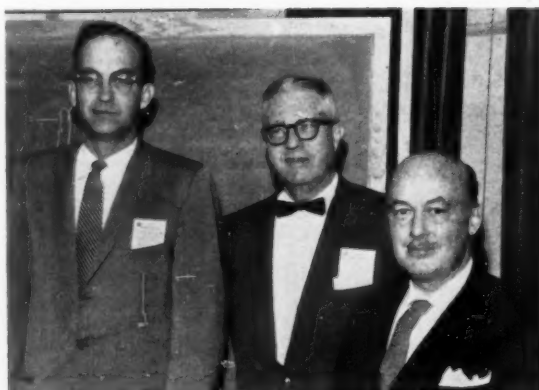


"BEHIND EVERY SUCCESSFUL MAN . . ."

A share of this honor must go to Mrs. Painter.

Mr. Painter was also for many years associate editor and business manager of the ASTM BULLETIN. It would be difficult, in fact, to find any area of Society or Headquarters operations in which Mr. Painter has not made distinct contributions, whether it be publications, finance, technical committee work, promotion and publicity, districts, or membership. He has, in short, "lived" ASTM for a period of three decades.

With such a broad background of experience in every facet of ASTM operations, we know that, as consultant to the executive secretary, the services of the Society's only Executive Secretary Emeritus will continue to benefit ASTM.



THE SOCIETY'S ONLY EMERITUS TRAVELED FAR AND WIDE IN THE CAUSE OF ASTM

(Top left) with past-president R. A. Schatzel at the 2nd Pacific Area National Meeting, Los Angeles; (top right) with past-president R. T. Kropf and Marburg Lecturer E. W. Pehrson, Boston; (bottom left) with William Gifford and past-president A. A. Bates, Hanover, N. H.; (bottom right) with a friend at the headquarters of the American Society of Tool Engineers (now ASTM), Detroit 1954.

ASTM MEETINGS

Date	Group	Place
Sept. 5-6	Committee D-23 on Cellulose and Cellulose Derivatives	Chicago, Ill.
Sept. 11-12	Committee C-22 on Porcelain Enamel	Cleveland, Ohio (Sheraton-Cleveland)
Sept. 13-15	Committee B-8 on Electrodeposited Metallic Coatings and Related Finishes	Washington, D. C.
Sept. 24-28	Committee D-2 on Petroleum Products and Lubricants	Detroit, Mich. (Statler)
Sept. 26-27	Committee F-2 on Flexible Barrier Materials	Natick, Mass.
Sept. 27-28	Committee C-21 on Ceramic Whitewares and Related Products	Bedford Springs, Pa.
Sept. 27-29	Committee C-16 on Thermal Insulating Materials	Williamsburg, Va.
Oct. 3-5	Committee D-10 on Packaging	Ottawa, Ont. (Forest Products Laboratory)
Oct. 4-5	Committee C-8 on Refractories	Bedford Springs, Pa.
Oct. 5-6	Committee C-3 on Chemical Resistant Mortars	Lake Placid, N. Y. (Marcy Hotel)
Oct. 9-11	Committee D-27 on Electrical Insulating Liquids and Gases	Virginia Beach, Va. (Hotel Cavalier)
Oct. 9-12	Committee B-5 on Copper and Copper Alloys, Cast and Wrought	Washington, D. C. (Willard)
Oct. 11-12	Committee C-14 on Glass and Glass Products	Bedford Springs, Pa.
Oct. 16-18	Committee D-9 on Electrical Insulating Materials	Montreal, P. Q. (Sheraton-Mt. Royal)

Annual Meeting Sets New Record

FOR THE SECOND straight year, registration records fell as a total of 3462 names were typed on as many badges at the 64th Annual Meeting of the Society, June 25-30, 1961, in Atlantic City. It took eight hotels and a motel to provide the meeting rooms for over a thousand committee meetings, 41 formal sessions and symposia, and ten informal sessions and panel discussions. It has been said, with some justification, that this meeting is the most complicated of its kind in existence.

President's Luncheon

In his address at the President's Luncheon, Tuesday, June 27, retiring president A. Allan Bates stated the need for ASTM to change to meet new circumstances. The Society must organize itself for quick action in a world of quick change. "The urgent challenges of today and tomorrow," said Dr. Bates, "no longer allow us to treat time as a plentiful commodity." He also pointed out the need for close liaison between the standardization activities of ASTM and the Materials Sciences Division. The full text of his address appeared in the July issue of *MR&S*.

At a business meeting following the luncheon, a vote of the members present plus absentee ballots was overwhelmingly in favor of changing the name of the Society to "American Society for Testing and Materials." This change will become effective after the necessary legal steps have been taken to change the charter.

Election of new national officers of the Society was announced in the July issue of *MR&S*.

Awards Luncheon

Speaking at the Awards Luncheon on Wednesday, June 28, Rear Admiral Martin J. Lawrence, assistant chief, Bureau of Ships, credited ASTM standards with a key role in the successful buildup of our naval strength for two world wars and for the present high-tension "coexistence." The complete text of Admiral Lawrence's address begins on page 641.

Recipients of honors and awards presented at the luncheon were announced in the July issue of *MR&S*.

Technical Highlights

Some of the highlights of the technical sessions and committee meetings are reported in the following pages.

Sessions and Symposia

Cumulative Fatigue Damage

Since most available fatigue data on materials is of the repeated-single-stress variety, and since most structures in service are subjected to a broad spectrum of stress amplitudes, researchers have long sought a workable hypothesis that would enable them to predict the service life of structures using the available data. The linear summation of cycle ratios, to which most work in this area is referred, has long been known to be an oversimplification. Three papers in the fatigue sessions attacked this problem.

S. S. Manson, A. J. Nachtigall, and J. C. Freche, NASA, proposed a method based on the hypothesis that lines representing the S -log N relationship of material prestressed varying amounts will intersect the S -log N line of the virgin material near a common point. Tests of SAE 4140 steel in rotating bending bore out the hypothesis, but the authors stated that much more experimental verification is needed before the method can qualify as a useful design tool.

Tests of 7075-T6 aluminum alloy wire specimens were reported by Robert Spitzer and H. T. Corten, University of Illinois. The authors concluded that the effect of sequence of stressing within the block in a repeated block test is small. They further concluded that the life of a specimen under continuously varying stress can be accurately estimated using their "modified S - N relationship" and an additional parameter that is determinable from two-stress repeated block tests.

W. H. Erickson and C. E. Work, Michigan College of Mining and Technology, studied the accumulation of fatigue damage in SAE 4340 steel and concluded that a characteristic number of crack nuclei are formed by the first cycles of stress, and further damage at other stress levels is confined primarily to propagation of these cracks. The number of cracks initiated is controlled by the initial stress level, and the rate at which they propagate is a function of subsequent stress amplitudes.

Fatigue Tests of Printed Wiring

The use of printed wiring is now very widespread in places where size and

Oct. 17-20	Committee D-13 on Textile Materials	New York, N. Y. (Sheraton-Atlantic)
Oct. 17-20	Committee D-20 on Plastics	Montreal, P. Q. (Sheraton-Mt. Royal)
Oct. 23-24	Committee D-14 on Adhesives	Buffalo, N. Y. (Statler)
Oct. 24-25	Committee B-9 on Metal Powders and Metal Powder Products	Detroit, Mich.
Oct. 24-25	Committee C-19 on Structural Sandwich Constructions	Buffalo, N. Y. (Statler)
Oct. 24-25	Committee C-25 on Ceramics for Electronics	San Francisco, Calif. (Jack Tar Hotel)
Oct. 26-27	Committee B-4 on Metallic Materials for Thermostats and for Electrical Resistance, Heating, and Contacts	Chicago, Ill.
Oct. 26-27	Committee C-20 on Acoustical Materials	Chicago, Ill. (University Club)
Oct. 30-31	Committee B-1 on Wires for Electrical Conductors	Washington, D. C. (Sheraton-Park)
1962		
Feb. 5-9	Committee Week	Dallas, Tex. (Statler-Hilton)
June 24-29	Annual Meeting	New York, N. Y. (Statler-Hilton)
Sept. 30-Oct. 5	Pacific Area Meeting	Los Angeles, Calif. (Statler-Hilton)
1963		
Feb. 4-8	Committee Week	Montreal, P. Q. (Queen Elizabeth)
June 23-28	Annual Meeting	Atlantic City, N. J. (Chalfonte-Haddon Hall)

64th Annual Meeting

weight of electronic components are limited. In many of these applications—for example air-borne equipment—there is considerable vibration and circuits are subject to fatigue damage. In their paper, "A Fatigue Test for Printed Wiring Boards and Through Connections," G. R. Gohn and A. Fox, Bell Telephone Laboratories, described a technique for studying the fatigue strength of printed wiring and through connections.

The authors modified a Krouse plate testing machine and shaped the printed wiring board into the familiar tapered cantilever beam specimen. They developed a monitoring system to indicate failure that responds when an open circuit of 3 millisecond duration occurs. The system can be modified to respond to open circuits of shorter duration.

Typical data were presented (plots of strain versus life) for copper-clad laminated epoxy-glass boards containing various types of through connections. Strain rather than stress was presented because, at the vibration amplitudes used in the tests, the strains in the conductors were mostly in the plastic region.

Nonmetals at Low Temperatures

Tensile strength and elastic modulus of reinforced plastics increase markedly as temperature goes down. Tests have been made at temperatures as low as -423 F. Morgan Hanson of the NASA Lewis Research Center in Cleveland told the Session on Low-Temperature Properties of Nonmetallics that a major reason for interest in reinforced plastics for application at very low temperatures is that these materials are not notch-sensitive and cracks do not propagate as they do in metals. The ratio of the strength with and without a notch will run about 0.9 for reinforced plastics, and much lower for most metals.

J. Hertz of General Dynamics described the use of nonmetallic materials in both the Atlas and Centaur space vehicles. Reinforced plastic laminates are used for fairings, nose cones, and various housings. Freon-blown polyurethane foams are used for thermal insulation. High-temperature pressure-cured adhesives are also used in space vehicles. Certain plastics are used in conjunction with liquid-oxygen fuel systems.

B. L. Taft of Pratt & Whitney reported experiments to determine explosibility of various plastics under impact conditions in liquid oxygen. The test used

is a somewhat crude go-no-go type. A weight is dropped on the specimen immersed in liquid oxygen with an energy of 70 ft lb; if the specimen explodes, it is not satisfactory for use in contact with liquid oxygen. Mr. Taft has tested several hundred materials, including both metals and nonmetals. The fluoro polymers such as Kel-F and Teflon have been found satisfactory, but the hydrocarbon types, epoxies, and silicones are not.

A. T. McPherson of the National Bureau of Standards observed that all the testing reported was empirical in nature. He urged that the investigators look into the fundamentals of materials behavior at cryogenic temperatures so that they might be in a better position to predict performance of materials on the basis of their structure. Some of the investigators commented that there is an urgent need for materials having satisfactory performance at cryogenic temperatures, and the empirical method is necessary to evaluate the materials available. It was stated that scientific investigations on materials are going forward concurrently in the same companies, but the large number of variables encountered in application of these materials makes it difficult to predict performance. Actual perform-

MARBURG LECTURE

How Ice Crystals Form and Grow

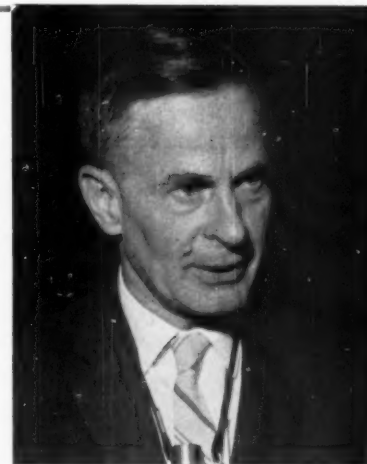
JACK FROST PAINTING spidery pictures on a windowpane offers a fascinating sight for the small fry and grownups alike, but how many of us really know in more than a gross qualitative way how these feathery crystals form and how the scientific knowledge of this phenomenon can be put to use? Thanks to Harvard's Bruce Chalmers, those who attended his Marburg Lecture on the nucleation and growth of ice crystals know a lot more than before and were fascinated by his account of how water can be supercooled much below the usual freezing point of 32 F before freezing takes place. He told how ice can form in supercooled water when the critical radius of an aggregate of molecules is exceeded for the prevailing temperature or the crystallization is triggered by some phenomenon such as the presence of suspended particles or by some dynamic action such as ultrasonic vibration or friction.

Ice can form with a smooth surface when the heat flow is through the ice to a heat sink, or it can grow

with an irregular surface when the heat flow is away from the newly formed ice. This latter type growth is called dendritic or tree-like because of its appearance. It is this dendritic growth that gives rise to the six-pointed star with the feathery branches so familiar in the snowflake or on the frosty windowpane.

Practical Problems—Frost Heaving

Knowledge of how water freezes and ice forms can explain why we have frost heaving—an extremely practical problem and one with substantial economic consequences. Such knowledge can then point the way to engineering solutions. Frost heaving occurs from the formation of ice "lenses" which can be explained on the basis of what is known about supercooling, nucleation requirements, and critical radius for freezing and the size of soil particles. Ice lenses form only when conditions are just right and depend on the relationship of the critical radius at the prevailing temperature to the radius of channels between soil particles. It is significant to point out that frost



BRUCE CHALMERS

heaving is *not* caused by the expansion that accompanies the freezing of water; it is caused by the forces drawing water from the surrounding soil, which builds up the size of ice lenses.

The frost heaving problem is not solved, but it now remains for the applied scientist—the engineer—to analyze various theoretical solutions in terms of economic feasibility. This course is likely to be much more fruitful than one based upon empirical results.

ance-type tests seem to offer the only reliable means for selection of materials.

Extension of Sensitivity for Constituents in Metals

With increasing demands for methods for determining metals constituents present on the order of parts per billion, or lower, it has been necessary to develop analytical methods having correspondingly increased sensitivity. Improved methods of separation, and in some cases concentration, of constituents to be determined were reviewed by J. L. Hague of the National Bureau of Standards. Included were more selective and sensitive reagents, ion-exchange methods of separation, and chromatographic separations. Electroanalytical methods of increased sensitivity, such as refined polarographic methods and anion stripping methods, were discussed by Louis Meites of the Polytechnic Institute of Brooklyn.

The capabilities of radioactivation analysis were discussed by G. W. Leddicotte of the Oak Ridge National Laboratory. Radioactivation analysis is based on measuring the radioactivity produced when a stable isotope, or isotopes, of the element being determined is bombarded by some type of nuclear particle—neutrons being the more usual particle, although protons, deuterons, alpha particles, and gamma particles have also been used. The method possesses limits of measurement of many

elements that are far below the range of other physical and chemical methods of analysis.

Usefulness of the electron probe as a specialized tool for measuring low average but high local concentrations was presented in the paper by L. S. Birks and R. E. Seebold of the U. S. Naval Research Laboratory. As little as 10^{-14} g of an element concentrated at a given point can be detected by means of the electron probe. Very useful information can be obtained as to the distribution of an element present in a very low average concentration. The amount and distribution of traces of impurities in alloys can readily be detected.

Of relatively recent application are mass spectrometer methods for analysis of solids. C. M. Stevens of the Argonne National Laboratory described the two more commonly used techniques—spark analysis using a double-focusing mass spectrograph, and isotopic dilution with chemical separation and isotopic analysis. Sensitivities as high as 10^{-9} have now been achieved for many elements, and sensitivities as high as 10^{-14} have been achieved for certain rare gases.

Nuclear Standardization Activities

At a Panel Discussion on Nuclear Standardization Activities, June 28, progress and status reports on nuclear

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standardization programs were heard from many ASTM technical committees and also from the American Standards Assn. and The American Society of Mechanical Engineers. The progress of the various "N" Sectional Committees in the American Standards Assn. and their relation with Technical Committee 85 on Nuclear Energy of the International Organization for Standardization were described in detail. The development of a Code for Nuclear Piping under ASA Sectional Committee B31 for Pressure Piping was covered. The work of the Special Committee on Nuclear Power of the ASME Boiler and Pressure Vessel Committee as well as the ASME Research Committee on Effect of Radiation were also described in special reports.

The exchange of information on the various activities should prove very helpful in avoiding duplication of effort.

Radiation Effects in Refractory Fuel Compounds

Since 1956, Committee E-10 has sponsored a Symposium on Radiation Effects on Materials every year. The first three of these, in 1956, 1957, and 1958, were sponsored jointly with the Atomic

GILLETT LECTURE

Kinzel States Need for Better Specifications

"SPECIFICATIONS?!" Thus was Augustus B. Kinzel's tenth Gillett Memorial Lecture deliberately titled. And one wondered at first whether the vice-president for research, Union Carbide Corp., might not be indulging in some leg pulling. But, as it turned out, there was method in Dr. Kinzel's madness.

"Specifications—question mark, exclamation point, period," said Dr. Kinzel at the beginning of his lecture. "The question mark pertains to the first part of this lecture: What is the purpose of a specification? What sort of historical evaluation has resulted in the nature of today's specifications? What use is being made of specifications and what abuses are involved?"

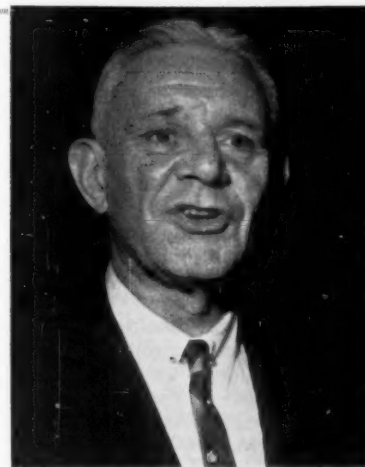
"The exclamation point pertains to the present astonishingly unsatisfactory state of the art, to the astounding lack of communication and pertinence in many specifications, and to the inexcusable waste

due to ignorance of materials, meaning of tests, and lack of understanding of engineering service requirements!

"The period pertains to the end result, Utopian no doubt, when the improvement of specifications and ways and means of keeping them up to date, made possible by really good engineering and reduction of ignorance will put an end to our present dilemma."

Dr. Kinzel mapped the path to that Utopia. To stay on that path, he said, we need to:

1. Write specifications for materials that have meaning with respect to the intended service and are precise and mathematical in character.
2. Find some way to provide variance from specifications without undue penalty and some way to specify the degree and nature of variance that is in accord with common sense.



AUGUSTUS B. KINZEL

3. Develop the nondestructive testing techniques—mechanical, chemical, etc.—that will assure us that tests verify the relationship of the material tested to that which is actually used.
4. Carry out engineering research in order to gain knowledge, in broad as well as in specific areas, and in this way to make a determined attack on the ignorance that underlies the factor of safety.

Industrial Forum. All five included papers dealing with a wide spectrum of radiation effects and were enthusiastically received. This year, Committee E-10 decided to depart from the general approach and to explore one subject in depth—radiation effects in refractory fuel compounds.

The symposium consisted of 12 papers given in three sessions on June 27 and 28 and a panel discussion in the evening of June 27. Organizations represented by the papers included Atomic Energy of Canada, Ltd., Oak Ridge National Laboratory, Bettis Atomic Power Laboratory, General Electric Co., and Battelle Memorial Inst. The audience included many recognized experts in the area of reactor fuels, and the papers and discussions were very informative.

As a result of the interest shown in this type of program, Committee E-10 has decided to sponsor another symposium in depth at the 1962 West Coast National Meeting, Sept. 30-Oct. 5, in Los Angeles. The subject will be radiation effects on structural reactor materials.

Destructive Liquids

The amazing destructive power of rapidly moving liquids was the central theme of a 6-paper Symposium on Erosion and Cavitation. The former is caused by the abrasive impact of moving liquids and the latter by the sudden collapse of minute bubbles after liquids have passed certain areas where partial vacuums have been created. When the bubbles collapse, the rapidly moving liquids act as miniature hammers on the container walls or on moving parts in contact with the liquids.

Olive Engel, National Bureau of Standards, showed that liquid drops striking a surface at a sufficiently high speed will not only create a crater-like hole on the impacted surface, but if a sufficient speed is obtained, a star-like crack will appear on the reverse side of the material. While it has not been conclusively shown, she speculated that the faster two objects meet in collision, the more they tend to have liquid-like properties. Thus, when a crater is formed on impact, the edge of the crater may be likened to a wave emanating from the point of impact. Miss Engel speculated that the crater-like formations on the moon can be likened to the waves caused by the impact on a semi-liquid moon surface of rapidly moving projectiles from space.

W. J. Rheingans, Allis-Chalmers Mfg. Co., reported that rapidly moving

Major Effects of Minor Constituents on Properties of Materials

A common aspect of solids, liquids, and ionized gases—that of impurity effects—was treated in this second major activity of the Division of Materials Sciences. The objectives of all the materials sciences symposia are several: that they be review and tutorial in nature, that they be interdisciplinary, and that they seek to bring about better understanding among engineers and scientists working in diverse materials fields. This and subsequent symposia sponsored by the Division will be published as part of the Society's Materials Science Series of Special Technical Publications.

THE CHANGES in the properties of materials that result from the presence of very small amounts of certain constituents were shown to have major effects on the suitability of materials for their intended uses. In some instances, as in standards for use in chemical analysis or in the determination of certain physical properties, any minor constituent is undesirable and the nearest possible approach to absolute purity is the goal. In other cases, the very large change in a property produced by a small amount of a minor constituent may be of great help in tailoring the material to its intended use.

Impurity effects in high-purity metals were discussed in the paper by L. L. Wyman and G. A. Moore of the National Bureau of Standards. The extreme care required in the determination of impurities, their effects, and their control were reviewed. The nature of occurrence of impurities, as well as their identity, were shown to have a major effect on the properties of high-purity metals. Some very desirable characteristics depend on careful control of very small amounts of impurities.

Ceramic materials properties also were shown by Ivan B. Cutler, University of Utah, to be markedly modified by the presence of small amounts of impurities, with electrical conductivity apparently most affected and with major effects on thermal conductivity, optical properties, and chemical reactivity. The influence of the minor constituents on crystal imperfections was found to be most significantly related to major changes in physical properties including structural, mechanical, electrical, and optical properties.

That organic structural polymers

can be modified in a number of ways by minor constituents was explained by John F. Lontz of E. I. du Pont de Nemours and Co. Significant changes in both physical and chemical properties were shown to result from structural changes resulting from minor constituents, both wanted and unwanted, with corresponding changes in processability, solid-state properties, and chemical endurance.

Small amounts of extraneous materials in petroleum produce major effects such as corrosion, gum formation, and catalyst poisoning in the processing of petroleum, according to H. M. Smith of the U. S. Bureau of Mines. Effects on physical and chemical properties have major influences on the suitability of petroleum products for end uses. Some of the desirable characteristics of present lubricants and fuels result from small amounts of additives. On the other hand some minor constituents are highly toxic, and certain hydrocarbons even when present in parts per million concentration have been found to be carcinogenic. For standards for use in analysis or measurement and for use in determination of fundamental properties, extremely high purity has been found to be essential.

Amazingly great effects of extremely small amounts of impurities in gases on energy levels of plasmas and on their behavior were reported by S. J. Buchsbaum of Bell Telephone Laboratories.

It was quite evident from this symposium that in the properties of materials the effects of minor constituents can be very great—that is, here too "it is the little things that count."

liquids often have sufficient power to create flashes of light when moving through turbines. These mysterious light flashes have never been fully identified. One hypothesis is that the energy of the moving water is used to some extent in the work of erosion and cavitation, also in the creation of heat at the impact point, and finally some of the energy either is converted directly into light or into static electricity, which when built to a sufficiently high degree, causes sparks to appear.

W. S. Mellquham, Dominion Engineering Works Ltd., gave an excellent slide presentation of cavitation in the process of taking place. In a series of elegant slides, the formation, buildup, and final collapse of bubbles on the blade of a turbine were demonstrated. In the background a curve giving a mathematical interpretation of the phenomena point by point was simultaneously projected.

The studies being undertaken to solve the problems of hydroelectric facilities are very much applicable to the problems now being faced by the explorers in space who find that rapidly moving meteoritic dust and traces of gases and liquids in outer space have very similar effects on the shells of rockets and satellites. Much of the work going on in the field of erosion and cavitation is being studied in connection with the preparation of rockets for space exploration. The destructive force of even a trace of water vapor striking a projectile moving at Mach 10 is enormous. Hardened material—some of gem-like consistency—can be badly damaged by even small droplets.

Impurities in Steam

As pressures and temperatures in boilers in steam power systems steadily increase, vaporous carryover of salts in the steam takes on increasing importance. Of particular interest is whether vaporous carryover of a given salt is stoichiometric with respect to the cation and anion involved. A report on a research project to investigate the mechanism of vaporous carryover of boiler water salts was presented by M. M. Rubright of the Babcock & Wilcox Co. Studies conducted in a small test boiler at a pressure of 2500 psig gave results indicating stoichiometric vaporous carryover of sodium chloride at low steaming rates (2 and 5 lb per hr). Some preliminary investigations at a pressure of 3000 psig failed, however, to show clear-cut evidence of a stoichiometric ratio in the vaporous carryover.

A research program to determine the extent of vaporous carryover of sodium salts in large, high-pressure (2500 to 2600 psi) boilers having full-load steaming rates from 1,200,000 to 1,600,000 lb per hr and in operation by public

utility companies was described by R. C. Ulmer and H. A. Klein of Combustion Engineering, Inc. An attempt was made to determine the agreement between volatility effects predicted by laboratory investigators and those observed under field conditions. Conditions of boiler operation and of sampling were carefully controlled. Sodium chloride concentration in the boilers was maintained at 10 to 25 ppm. Results appeared to show that vaporous carryover of sodium salts from boilers operating at 2600 psi or less should not present a serious problem so long as the salt concentration in the boiler water is maintained within reasonable limits.

In investigations of steam purity, sampling methods are of the greatest importance, since the analytical methods used permit measurements in the parts-per-billion range, and such precision is of little value unless the sample is truly representative. The precision of measurements in parts per billion may be dramatized by pointing out that there are about a billion people now on the face of the earth. However, a boiler that produces more than a million pounds of steam per hour may pass several hundred pounds of impurities to a turbine in a year's time, so that accurate determinations of such small concentrations of impurities can be very significant. Even though the steam taken for the sample may be representative of the steam being produced at that time, impurities may separate out in the sampling equipment so that the sample finally collected for test is no longer truly representative of the steam that was sampled. Investigations of the problem and details of a sampling system developed to eliminate deposition of impurities were described by R. V. Cobb and E. E. Coulter of the Babcock and Wilcox Co.

Properties of Rare Metals

S. L. Ames of the Allegheny Ludlum Steel Corp. discussed the tensile properties at 600 F of annealed Zircaloy 2 in a number of mill product forms. The tests were conducted under conditions outlined by the Navy as acceptance tests for Zircaloy 2 in their nuclear propulsion program. Mr. Ames concluded that the tensile properties of annealed Zircaloy 2 in different mill product forms vary over a considerable range. These variations can be attributed to differing degrees of directionality developed in fabricating to the various final forms. Transverse specimens have lower tensile strength, higher yield strength, and greater ductility than longitudinal specimens. Vacuum annealing as opposed to air annealing caused a deterioration in strength properties, particularly the

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ultimate strength. The reason for this was not established. There was a wide spread in properties even in materials with similar process history. Yield strength and possible tensile strength of Zircaloy 2 appear to be dependent on the type of tension specimen used. Flat specimens give higher values than round, and reduction by machining of the thickness of flat specimens also resulted in higher strengths.

M. Semchyshen, Climax Molybdenum Co. of Michigan, described work that verified the strain-rate sensitivity of molybdenum. Yield strengths were found to be sensitive to elastic strain rates and tensile strength to plastic strain rates. Ductility was not particularly sensitive over the range of strain rates studied. Strain aging was concluded to be an important factor in the mechanical behavior of molybdenum. The structural applications of molybdenum have multiplied appreciably in the past decade. The greater use of this metal and its alloys has been predicated on its availability in large sizes, and increased use of the metal for structural purposes requires the establishment of standard specifications for quality control and purchasing. Mr. Semchyshen commented that as a result of his studies he believes we should tighten our methods of tension testing for even such plebeian materials as iron. Some suppliers are able to get around specifications when the methods of making the tests and the specifications are prepared too loosely.

Compressive, Shear, and Bearing Creep

Data on the creep characteristics of metals is essential for selection and design of structures that must sustain loads at elevated temperatures. There is a great deal of such data available for tensile loading, but for many elevated-temperature applications, compressive, shear, or bearing loads are critical. Investigations of the creep characteristics of metals subjected to such loads are clearly needed.

Facilities to determine these properties of sheet metals at temperatures up to about 1200 F were described by J. R. Kattus and H. L. Lessley of Southern Research Inst. The compressive and bearing determinations were carried out in loading fixtures containing cartridge heaters as integral parts. These heating units, which obviated the need for conventional furnaces, provided good temperature uniformity. Also, accurate strain measurements were possible because the extensometer was

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positioned quite close to the specimen. Shear creep-rupture determinations were carried out on both sheet-type and pin-type specimens in conventional creep furnaces.

Commercial creep machines were used for bearing and shear loading, while special loading frames designed and built at Southern Research were used for compression loading. Buckling in the specimens was prevented by nickel support blocks lubricated with molybdenum disulfide to minimize friction. The cartridge heaters were inserted in these blocks. Temperature uniformity of ± 3 F over the 2-in. gage length was maintained up to at least 1000 F. The compact design of the compression fixture permitted the use of a compact extensometer with the transducer mounted only 3 to 4 in. from the specimen. This type of extensometer design minimizes possible mechanical errors generally associated with long extension arms used with conventional furnaces.

The authors presented their results in the form of design-type creep curves for various types of loadings using specimens of titanium alloy sheet. Although the data and procedures are believed to be valid, the authors recognized the need for verification and possible improvement in these determinations. They also expressed the hope that this work would stimulate activity that could lead to the development of standard procedures for determining these properties.

Elevated-Temperature Compression Testing

The spectacular successes of air-breathing jet engines and rocket devices are due in large measure to the development of special structural materials capable of withstanding the extremely high operating temperatures and stresses. Design engineers working on these devices have done excellent work despite such major handicaps as the lack of sufficient mechanical property data for candidate materials under service conditions.

Where high temperatures are encountered in aerospace applications, the design problems are formidable, because weight must be kept to a minimum. It is in this area that the science of design is receiving much attention.

The short-time or transient condition of high temperature and high stress in structural components was considered by E. C. Bennett and W. W. Gerberich of the Jet Propulsion Laboratory,

California Institute of Technology. They described equipment and techniques for studying rapid-rate compression stress-strain behavior and short-time compression-creep properties of sheet materials at temperatures ranging up to 2000 F.

The compression tests were carried out on an automatically controlled machine developed specifically for high-speed testing. The specimens were flat double-pin type with an ASTM standard gage section. They were heated at rates of 200 F per sec by electrical self-resistance. Commercial alumina ceramic rollers were used to minimize frictional loads generated between the specimen and lateral supports.

Sheet materials evaluated on this equipment included 2024-T81 aluminum alloy, 17-7PH-(TH1050) steel, 6Al-4V titanium alloy, and a 20Cr-20Ni-20Co iron-base alloy. The authors presented summary data tabulations of compressive strength, elastic modulus, and tangent modulus. Compression creep and yield strength curves were also presented. The data clearly demonstrate that strain rate has a major effect on the measured strength, especially at high temperatures. Tests also showed that creep deformation can be a critical factor, even when the time involved is on the order of a few seconds or less.

Metals at Low Temperatures

The primary requisite for steels for low-temperature service is a high fracture toughness—the ability to resist the rapid crack propagation associated with brittle failure. This is a matter of great importance in the development of rockets and missiles.

New concepts and design problems in this area were explored in a three-session symposium on the Evaluation of Metallic Materials in Design for Low-Temperature Service. Experts in the aeronautical, steel, and petroleum industries presented papers that focused on the behavior of metals at temperatures down to that of liquid helium (-452 F). The broad scope of the papers in this symposium was dictated by the demands of design engineers for more information on the characteristics of metals in cryogenic service.

J. E. Srawley and C. D. Beachem described a procedure for introducing small surface cracks into high-strength steel sheet specimens. The authors, both from the Naval Research Laboratory, demonstrated the effect of crack size on tensile strength for two steels having comparable yield strengths but different levels of fracture toughness at room temperature. Small, semi-elliptical cracks were induced by stressing the specimen and causing an electro-

chemical process to occur at a selected part of the surface. A considerable range of crack sizes was obtained by this technique.

The authors concluded that if the crack is small compared with the width of the specimen, the effect of the crack on the strength is almost independent of the width. "On the other hand," they pointed out, "comparison of results for crack-slotted specimens with those for the surface-cracked specimens show that, in general, a surface crack has a more damaging effect than might be expected from the results of tests on the commonly used slotted or edge-notched specimens. In the present state of knowledge the effect of a small surface crack cannot be predicted from the results of tests of slotted or notched specimens."

A. A. Wells of the British Welding Research Assn. presented fracture data for welded plates. He pointed out some of the shortcomings in present test requirements in steel product specifications and in British and American pressure vessel codes.

"The greatest difficulty facing the engineer at this point is selection of a test method and criteria for the determination of a steel's resistance to brittle fracture," Mr. Wells stated. "Test procedures adequate for this purpose are available as research tools, but there does not yet appear to be a simple test which would be suitable, or acceptable to steelmakers generally, for incorporation in purchase specifications as a routine acceptance or rejection test. At this time the only test available to the engineer is the Charpy impact." In spite of its shortcomings, the author concluded, "this test must continue for some time to form the basis for generally used production steels."

Soils

Illustrating the many factors involved in the study of soils for engineering purposes, a group of papers was presented at the Soils Session which covered a variety of subjects. One paper, presented by R. F. Leggett, representing the authors W. J. Eden and J. K. Kubota, National Research Council of Canada, gave some observations on the measurement of sensitivity of clays. Four methods were described in detail covering the field vane, the laboratory vane, the unconfined compression test, and the fall-cone test. The authors felt that measurement of an undrained shear strength of a clay is a better criterion to describe soil properties than measures such as the liquid index. It was found that the present methods of measuring sensitivity cannot be expected to yield consistent results. The field vane method is probably the most

economical, and the fall-cone test is the most convenient and economical of the laboratory methods. However the authors had reservations on the precision and interpretation of the test results.

The influence of strain on shearing resistance of sensitive clay was the topic of a paper by C. B. Crawford, also of the National Research Council of Canada. Since the effective-stress shear-strength parameters of a sensitive clay are subject to a wide degree of interpretation because the pore water pressure does not reach equilibrium at maximum stress, a series of tests was conducted in an effort to interpret the results in terms of fundamental parameters. Consolidated-undrained triaxial tests were performed on samples of a late glacial marine clay. Conclusions drawn were based on relatively few consolidated-undrained test results, with some evidence of a certain general applicability, but the extrapolation of test results on sensitive clays was felt to be hazardous.

With various types of organic and inorganic materials being used as soil stabilizing agents, it has been found desirable to evaluate such materials under varying treatment conditions in order to select the proper material for use with a given soil. The use of the unconfined compressive strength test for this purpose was described by C. A. O'Flaherty, with H. T. David and D. T. Davidson as coauthors, all of Iowa State University. An appraisal was made from a statistical point of view using triplicate sampling and replacing the commonly used "blanket" disqualifying percentage by a similar percentage tailored to the specific investigation. It was found that nomographic procedures used proved to be quite simple.

Quantitative Determination of Soil Montmorillonite by X-ray Diffraction was the title of a paper presented by G. R. Glenn, Southern Illinois University, with R. L. Handy, Iowa State University, as coauthor. With montmorillonite exerting a strong influence on soil properties, the authors were concerned with determining the best qualitative method for clay mineral identification and used the X-ray diffraction method for this purpose. The paper includes a detailed description of the X-ray diffraction procedures used, the calibration curves developed, and correlations found. The authors concluded that the montmorillonite content of air-dry natural soils can be reliably measured by X-ray diffraction with an internal standard employing a correction for variation of intensity due to configurations of interlayer water. The correlations were found to be on a par with the data of the pipet analysis.

Road and Paving Materials

A laboratory-field study of hot asphaltic concrete wearing course mixtures was described by J. F. Goode, U. S. Bureau of Public Roads. The extent of degradation of dense-graded aggregate in hot asphaltic concrete during construction and under subsequent traffic was the principal item covered. A joint project of the Physical Research Division of the Bureau of Public Roads and the Maryland State Roads Commission provided the technical data which covered degradation caused by compaction and by traffic as well as changes in pavement density. Air voids and their relation to pavement performance and asphalt hardening were discussed. A limited number of test sections for the variables encountered in the study did not warrant specific conclusions. The author felt justified in stating that only minor degradation of the aggregate occurred during construction compaction and under traffic and was not considered sufficient to affect the surface behavior of the pavements. It was not felt unreasonable that pavement densities would be in the range of 97 or 98 per cent of the minimum allowable percentage of laboratory density. Rapid hardening of the asphalt resulted from a high content of air voids in the pavement. Initial air void content should be no greater than 9 per cent after adequate compaction.

The significance of variation of bitumen content in paving mixtures was discussed by J. H. Keyser, City of Montreal Testing Laboratory, with N. G. Gaudette, State Highway Commission of Wisconsin, as coauthor. It was pointed out that precise measurement of bitumen content consistency is limited to the representative state of the sample and the accuracy of the extraction procedure. The chief purpose of the paper was to present information concerning variation in bitumen content that can be expected in centrifuge extraction test results for several common sampling

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conditions. Considering the variations inherent in sampling, extracting, and unavoidable variation in bitumen content and aggregate gradation, it was concluded that a standard deviation of 0.2 per cent bitumen is normal, and that 0.6 per cent was a realistic tolerance specification, assuming normal distribution. A recommended specification for bitumen tolerance is included in the paper.

Soil Dynamics

Prof. R. K. Bernhard, Rutgers University, presented the results of a study to determine principal stresses and maximum shear stresses in noncohesive soils subjected to sinusoidal loads. Normal stress measurements were made in the field and compared with the elastic theory. Professor Bernhard's conclusions, based on one type of almost noncohesive soil and one frequency and magnitude of vertical force, were that special precautions are essential when inserting pressure cells into the soil; the placing of pressure cells under different angles permits a check of the resulting readings; and the normal stresses indicated a standard deviation of approximately 5.2 and shear stresses of approximately 3.3 per cent.

A study of earthquake effects led to research under the direction of Prof. F. J. Converse, formerly of California Institute of Technology and now with the Converse Foundation Engineering Co. Undisturbed samples of soft saturated mud were subjected to oscillating direct shearing forces in order to establish the modulus of rigidity and the energy loss per cycle under conditions occurring during strong earthquakes. This study was made in connection with the proposed Trans-Bay Rapid Transit Tube across San Francisco Bay. A simi-



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lar study was made for a bridge across the Tagus River, Lisbon, Portugal. The author described the test specimens and equipment, calibration, and test procedure used. It was determined that the major factors affecting the shearing modulus of soft mud under reversals of stress are the magnitude of the deformation and the frequency of the oscillation.

The U. S. Army Engineer Waterways Experiment Station, as part of a project on nuclear weapons effects on structures, terrain, and waterways, undertook a research study of the dynamic-bearing capacity of soils. The objective of the study was to develop criteria for the design of foundations subjected to dynamic loads. A paper presented by R. C. Sloan, coauthor with R. W. Cunney, described the test apparatus and small-scale footing test used. Of particular interest was the dynamic loading machine designed for the purpose, which was pneumatically and electrically controlled. Static and dynamic load tests were conducted on sand as well as on clay. The testing apparatus was considered quite satisfactory for use in the laboratory test of small-scale footage. Owing to the preliminary nature of the test reported, an analysis of the data relative to the behavior of the footing foundation under dynamic loading is premature. One observation was, however, that the deformations measured at three corners of the footing were remarkably uniform. A second observation was that the time-deformation plot for a particular dynamic test on sand suggested that footing deformation under failure loads occurs in a two-stage motion.

Cement

At the Session on Cement, the "Significance of Selected ASTM C-1 Tests" was discussed by selected experts in their respective fields. W. C. Hansen, consulting chemist, described the evolution of ASTM Method of Test for False Set of Portland Cement (Mortar Method) (C 359), comparing it with the Method of Test for False Set of Portland Cement (Paste Method) (C 451). T. B. Kennedy of the U. S. Army Engineer Waterways Experiment Station discussed the Method of Test for Calcium Sulfate in Hydrated Portland Cement Mortar (C 265). The Method of Test for Potential Sulfate Resistance of Portland Cement (C 452) was evaluated by William Lerch of the Portland Cement Assn. M. A. Swayze, Lone Star Cement Corp. (retired), traced the history of testing mortar prisms for flexural strength, referring to Methods C 109, C 348, and C 349.

In his paper on "Investigation of Concrete Materials for a Major Project in Western Canada," G. C. Price of the Canada Department of Agriculture showed that the addition of fly ash to fixed cement factors resulted in slightly reduced water requirement, improved workability, and satisfactory early and long-term strength gain. Sulfate resistance studies showed the superior performance of type V over type I cement, the value of increased cement content, improved potential sulfate resistance with fly ash additions, and slightly decreased resistance with pumicite additions.

An improved automatically controlled adiabatic calorimeter for determining the temperature rise of mass concrete was described by David Pirtz of the University of California. The calorimeter consists of an outer chamber maintained at a controlled temperature slightly below that of the inner chamber, in order that the inner chamber need never be cooled. A row of resistance thermometers is mounted across the section of concrete specimen and its immediately surrounding insulation, and the temperature across the specimen is maintained practically constant.

A discussion of "The Mechanism of Grinding Aids" by F. J. Mardulier of the W. R. Grace and Co., Dewey and Almy Chemical Div., was helpful in understanding how grinding aids function and how to get the most out of their use. The author stated that it is just as necessary to adjust a grinding mill mechanically to control mill retention time and assure optimum, or at least constant ratio of weight of grinding media to weight of clinker, as it is to adjust an automobile carburetor to the octane rating of the gasoline used so that maximum savings in gasoline consumption may be realized. The relationship between mill retention time and circulating load, and the ratio of grinding media to clinker charge were shown.

New Techniques in Concrete

Neil B. Mitchell, Jr., Cornell University, described at the Concrete Session an indirect tension test for concrete which he suggested would prove worthwhile for field control of high-strength concrete. The test, which consists of crushing a cylindrical specimen by placing it on its side between the loading surfaces of the testing machine, was compared with tension tests. Failure of the specimen occurs by tension on the plane passing through the two sides where the load is applied. Failure starts in the central part of the specimen and is not affected by surface conditions such as crazing, or wall effects. The test, therefore, is said to be free from those conditions which ordinarily cause pre-

mature failure of a test specimen. The author considers the indirect tension test superior in most aspects to other tension tests now in use or proposed.

The correlation of flexural and compressive strengths of concrete and mortars was described by Ivan L. Lynn in a paper by Lynn and Kenneth E. Palmer. Statistical correlations of various flexural and compressive strengths of laboratory prepared concretes and mortars using 37 type I, II, and III cements from different parts of the United States were reported. In addition, the investigation covered mortar compressive strengths for cubes, modified cubes, and prisms. Concrete compressive strengths were compared for 3 by 6 in. cylinders and flexural strengths were compared for midpoint loading of 3 by 3-in. prisms with a 9-in. span. Highly significant correlation equations for several strength relationships were presented for each of the cement types.

The authors concluded that excellent correlations exist between various strength test results, and that once the equations are determined they can be used for computing other strength results. The development of equations for various cement types is not required, since the regression equation for the combination of all cements is not significantly different from those for the individual types.

An extensive discussion of experimental short-time loading tests made on portland cement concrete cylinders to study relative strain-sensing capabilities of mechanical and resistant strain gages was presented by John R. Keeton, of the U. S. Navy Civil Engineering Laboratory, Port Hueneme, Calif. The determination of end-to-end strain distribution using both types of gages as well as photoelastic coating technique revealed extreme variations of strain both inside the concrete and along the outer surface of the cylinders. The comparative test, according to the author, indicated that strain measurements made with devices containing electrical resistance elements are more reliable because they show little effects of the test variables. Tests with the photoelastic coating techniques indicated that contours of maximum shear strains follow no set rule regarding mortar and the larger aggregate. The concrete acts like a rigid skeleton in which the strains are distributed indiscriminately around, across, and among pieces of large aggregate and the mortar which surrounds them. The general belief that strain distribution in concrete is nonuniform was substantiated in the study. The author concluded that when mechanical strain gages are used, metal disks (outserts) cemented to the concrete surface serve as better reference points than inserts, because they are not affected by inter-

nal concrete strains; and extreme strain fluctuations preclude the use of gages having a length shorter than 5 in. if average strain of the specimen is desired.

W. E. Tefft, physicist, National Bureau of Standards, described techniques for exciting, detecting, and measuring the mechanical resonance frequencies of solid specimens and for computing the elastic moduli from these resonance frequencies. The techniques described are applicable to any material that is sufficiently elastic to be vibrated in resonance. If the material is also homogeneous, isotropic, and of the appropriate shape, the computations described are applicable. The resonant frequencies have many useful diagnostic applications (for quality control, for example) even when the elastic moduli are not calculated from them.

Stress Relaxation

The maximum utilization of engineering materials required by modern design demands the quantitative evaluation of mechanical properties which previously were either ignored because of difficulties encountered in their determination or were estimated from other more readily measured properties. One of these properties, stress relaxation, was discussed in a paper by G. R. Gohn and A. Fox, Bell Telephone Laboratories. Stress relaxation causes the drop in pitch frequently observed in stringed instruments, but more important from an engineering standpoint it governs all thermal and mechanical processes used for the relief of residual stresses. Relaxation also tends to even out stress gradients resulting from geometrical factors and nonuniform loads in working parts. Hence stress-relaxation data can be utilized, not only to develop stress-relief treatments which may be used to lessen residual stresses in castings, forgings, welded assemblies, cold-worked metals, machined surfaces, etc., but also to obtain basic information on the permanent tightness of bolted joints, riveted assemblies, shrink fits, gaskets, solderless-wrapped connections, and similar devices. Useful engineering data on stress-relaxation in compression can be obtained on a large number of specimens in a minimum amount of time by employing a limited creep test device such as that developed by the authors.

Heat Release in Building Fires

The extent to which building materials burn and release heat during building fires is considered of importance by code officials. Because of this, building codes generally contain requirements with respect to the "noncombustible" properties of materials to be used in

different portions or types of buildings. The test methods most frequently used for measuring this property have been qualitative in nature. A new method for measuring potential heat for building materials with the objective of providing an indication of heat release likely to occur during building fires was described in a paper by J. J. Loftus, D. Gross, and A. F. Robertson, National Bureau of Standards.

Microviscometry

The sliding plate microviscometer, an instrument for measuring the viscosity and consistency of asphalt, was the central topic of the Symposium on Microviscometry. This instrument consists of two small plates, between which a very thin film of the material to be tested is applied. One of the plates is attached to a balance-like arrangement. The force necessary to pull one plate along the surface of the second is measured in the balance-like arrangement and gives some indication of the viscous properties of the material being tested.

Sessions and Symposia

Since asphalt is a complex mixture of organic materials often containing extraneous material, the physical properties are difficult to define. Sometimes asphalt acts as a liquid and at other times it has the properties of a gel. Asphalt technologists, highway engineers, and others concerned with the use of asphalt for highways have found that for engineering purposes a clear understanding of the viscous properties of the material is extremely important. The exact measurement of viscosity in asphalt is not a simple matter, and this symposium centered on one method that appears to have promise. While the instrument cannot be used for quality control purposes at this time, it appears that it may be used for research work with the hope that it eventually can be developed into a control apparatus.

Atlantic City to Bermuda

AT THE CLOSE of the Annual Meeting, a party of 31, including ASTM members and members of their families, boarded a special bus in Atlantic City which took them to Idlewild Airport for the flight to Bermuda. Miss Marie Ounan, Headquarters representative on the trip, reported that the ideal weather during the ensuing five days provided ample opportunity for a thoroughly enjoyable post-Annual Meeting Conference.

At the Princess Hotel on July 3, the conferees heard William M. Cox, author of "Bermuda's Beginning," review the geological history of the islands. He told of their volcanic origins and of the part played by the sea, the Ice Ages, and the elements in their subsequent devel-

opment. He described the processes whereby the sand dunes, the caves, the coral reefs, and the rich red soil of Bermuda came into being.

Ernest D. Ede, Fellow of the Royal Institute of British Architects, told of the many problems of construction materials that must be overcome in the islands because of the highly corrosive environment. At the end of his talk, those present asked numerous questions concerning the use of specific materials, such as concrete block, stainless steel, plastics, paints and sealants, copper tubing, and concrete aggregate.

The remainder of the five days were devoted to nontechnical exploitation of such delightful elements as sun, sand, surf, and scenery.



CONFEREES AT IDLEWILD AIRPORT BEFORE FLIGHT TO BERMUDA

Technical Committee Notes

Following is a brief glimpse inside the meeting rooms of the technical committees at the 64th Annual Meeting.

Steel (A-1)

An important revision of Specification A 325 was approved so that only high-strength bolts for structural steel joints will be covered. A new specification covering high-strength bolts for other than structural purposes has also been approved.

The committee is considering the withdrawal of Specification A 8 for structural nickel steel. Investigation indicates that there is very little, if any, of this steel being produced. A revision of Specification A 94 for structural silicon steel is under way to cover material of 50,000 psi minimum yield to 1½ in. in thickness. Also an investigation is being conducted as to whether ASTM should promulgate specifications for the various weldable heat-treated construction steels.

A proposed revision of the marking requirements for deformed bars for concrete reinforcement furnished to ASTM Specifications A 16, A 160, A 408, A 431, and A 432 will require size and grade identification. Action was tabled on the preparation of a 90,000 psi minimum yield strength reinforcing bar specification, since there was no indication of general industrial use of this product. It is planned to revise Specification A 16 and to prepare a separate document for rail steel reinforcement with a minimum yield strength of 60,000 psi.

Other new specifications proposed for development include those for:

¶ Forgings for gears for industrial or general use, to be coordinated with specifications developed by the American Gear Assn.

¶ Castings for highway bridges.

¶ Weldable low-alloy steel castings for gas transmission lines.

¶ Condenser and heat-exchanger tubes with integral fins, made of carbon, alloy, and austenitic steels.

¶ High-strength large-size bolting for the nuclear industry.

Participation in ISO Technical Committee 17 on Steel was reviewed after a year's activity. Four U.S.A. delegates attended the week-long April, 1961,

meeting of TC 17 in London. There is a tremendous amount of work now proceeding on the development of ISO recommendations for testing steel and for specification requirements. At the April meeting twelve test methods (including hardness, impact, tension, ring expanding, creep, fatigue, and carbon and silicon analysis) were approved for letter ballot. Recommendations for general technical delivery requirements for steel and for selection and preparation of test specimens were also approved for letter ballot. Activities under way in working groups include two specifications for structural steel, two specifications for quenched-and-tempered steels, additional analytical methods, and methods for the Jominy hardenability test and for grain size measurement. A new working group has been established to draft an ISO recommendation for design of structural steel sections.

Committee A-1 also recommended to the Society U.S.A. participation in an International Deep Drawing Research Group. Several representatives of companies in the U.S.A. attended a symposium sponsored by the international group last year.

Corrosion of Iron and Steel (A-5)

Four new specifications in various stages of completion were reported: corrugated steel fabricated pipe (84 in. maximum diameter), corrugated steel for structures assembled in the field (60 in. minimum diameter), aluminum-coated steel sheets for heat-resistant applications, and aluminum-coated chain link fencing.

The new atmospheric exposure test study of aluminum-coated wire and wire products to be exposed at seven test sites has begun. Changes in physical appearance and tensile strength data will be collected during the years of exposure.

A recommended practice for the use of hand-held magnetic gages to determine non-ferrous metal coatings on iron and steel was reviewed. The supporting interlaboratory data for this method has been statistically analyzed and is being reviewed.

Malleable Iron Castings (A-7)

Provision was made for elevated temperature use of standard malleable iron castings covered by Specifications A 47 and A 220.

Gordon B. Mannweiler, chairman of Committee A-7 Subcommittee VII on Corrosion, presented a very complete report on "Corrosion Test Results on 15 Ferrous Metals After 1-year Atmospheric Exposure" which covered malleable iron, ductile iron, and rolled steel plates exposed at marine, industrial, and rural sites located in North Carolina, New Jersey, Pennsylvania, Indiana, and California.

Non-ferrous Metals and Alloys (B-3)

A report on galvanic and electrolytic corrosion of plate-type galvanic couples was presented. In this study two magnesium-base alloys were coupled to seven aluminum alloys, mild steel, type 304 stainless steel (plain and chromium plated), red brass, and monel. The first year of exposure showed that the seven aluminum alloys had the least galvanic corrosion when coupled to either of the magnesium-base alloys, although all of the aluminum alloys were approximately equivalent in their galvanic effect on these magnesium alloys. There was no significant difference between galvanic corrosion caused by high-purity and commercial-purity aluminum alloys. The magnesium alloys suffered the severest galvanic corrosion when in contact with brass, monel, mild steel, and stainless steel.

The apparatus designed to measure time-of-wetness and temperature of the specimens and the SO₂ content of the atmosphere has been in operation for almost six months. The copper, zinc, and steel panels exposed with this apparatus have been withdrawn from exposure over this period and data are presently being developed to determine how well the apparatus functions in a variety of environments.

The one-year exposure specimens of 77 non-ferrous metals and alloys exposed at four test sites are being assembled. The two-year specimens have recently been withdrawn for testing.

The Cass and Corrodokote corrosion test methods developed by the American Electroplaters' Society for electroplated coatings have been approved by the committee for publication by the Society.

Cement (C-1)

Several revisions were acted upon for changes in the Specification for Portland Cement (C 150), and for Masonry

Cement (C 91), which will bring corresponding Federal and ASTM specifications more nearly in line.

A new tentative specification for apparatus to be used in the measurement of the volume change of cement paste, mortar, and concrete was reported, and the specifications for natural cement (C 10) were extensively revised. A number of tentative methods of chemical analysis of portland cement, having undergone extensive trials, were adopted as standard as either optional methods or as replacements for the previous standard methods. The limits on the autoclave expansion of portland cement were increased from 0.50 to 0.80 per cent, and the procedures for calculating the assumed compounds in portland cements were substantially expanded.

Some helpful new information about false set in portland cement was made available through the publication of definitions for some of the more commonly used terms, and the data obtained from a recent comparative test program in which more than 10 laboratories participated are being reviewed preparatory to introducing certain refinements in the methods for determining false set. Also, specification requirements for false set based on these methods of tests are being formulated. Much needed information about the equipment used in determining the flexural strength of hydraulic cement mortars was made available, and a number of clarifications in the procedures to be used in sampling hydraulic cements were presented. Attention is being given to some new problems with standard sands which have been encountered in recent months.

Increased attention is being given to international methods of test and specifications for cements following the designation of Committee C-1 as the U.S.A. group advisory to the American Standards Assn. in the work of ISO/TC 74 on Hydraulic Binders.

Clay Pipe (C-4)

A new specification for vitrified clay liner plates will be presented to the Society through the Administrative Committee on Standards for acceptance. The specifications cover plates to be used to line or face pipe, culverts, abutments, structures, or appurtenances composed of materials which may be subject to corrosion or erosion due to acid, alkali, or scouring waste water and other liquids.

It was agreed to include requirements for extra-strength perforated pipe in the existing Specification for Standard Strength Perforated Clay Pipe (C 211). Methods will be developed for testing shorter length pipe.

Lime (C-7)

A close liaison will be established with the American Water Works Assn. in connection with the development of specifications for lime for water treatment. The committee has expressed concern over the requirements for lime included in a recent Federal Interim Specification and will plan to effect liaison with the Government agency responsible for the development of the specification.

The development of specifications for lime for use in the steel industry was not considered feasible owing to the variation in individual plant requirements. A new method of test for determining the available lime, developed by the Texas Highway Dept., is being reviewed by the responsible subcommittee.

Concrete and Concrete Aggregates (C-9)

A Manual for Concrete Testing, in preparation for some time, will be ready for presentation to the committee at its fall meeting.

Some new projects under way include: Collection of data from various sources to establish the experience with

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vibrated test specimens; round-robin tests on liquid membrane-forming compounds; a test program to refine the test methods dealing with hardened concrete; completion of a test program for obtaining data on abrasion testing apparatus on concrete floors; and collection of information on the evaluation of aggregates by freezing and thawing in concrete.

The Subcommittee on Admixtures reported a full program of research leading to the development of specifications for chemical-type admixtures. Proposed specifications should be available during the coming year. A very extensive program of collecting data on fly ash has been completed but not yet analyzed.

The Subcommittee on Organic Materials for Bonding, Patching, and Sealing Concrete plans to develop performance requirements for all types of materials, particularly the epoxy resins.

A proposed method of test for compressive strength of insulating concretes was agreed upon. Revisions in existing specifications for lightweight aggregates (C 330, C 331, and C 332), were accepted in the subcommittee for later action by Committee C-9.

Gypsum (C-11)

A cooperative test program on the performance characteristics of perlite plasters has been initiated in which five cooperating laboratories will participate. Four sources of perlite aggregate will be used, one of which will be a treated aggregate. The test will be limited to compressive strength and shrinkage, with parallel tests being made with plaster and standard sand.

Substantial revisions were accepted in the Methods of Physical Testing of Gypsum Board Products and Gypsum Partition Tile or Block (C 473), including the addition of procedures for determining the flexural strength and nail retention of precast reinforced gypsum slabs.

Mortars for Unit Masonry (C-12)

A task group has been authorized to study organic-type mortars, as well as admixtures, and to report at the next meeting of the committee.

Results are incomplete on a series of cooperative tests conducted in eight laboratories on the five types of mortars covered in the Specification for Mortar for Unit Masonry (C 270). When this

A. W. Tracy Feted at Luncheon

DURING THE Annual Meeting, a luncheon was held by Committee B-3 on Corrosion of Non-ferrous Metals and Alloys for A. W. Tracy, secretary of the committee for 20 years. The luncheon was attended by many of the long-time members of the committee. T. A. Marshall, Jr., ASTM executive secretary, noted the long, continued service of Mr. Tracy to ASTM and to Committee B-3. Sam Tour, former chairman and secretary of the committee, spoke of the early work of the committee and the role that Mr. Tracy has played in its activities over the years. W. H. Finkeldey paid tribute to Mr. Tracy's efforts in expediting the work of the committee during his long period as secretary. F. L. LaQue reviewed Mr. Tracy's activities in the field of corrosion in ASTM, in the Electrochemical Society, and in the Gordon Research Conferences on corrosion. On behalf of Committee B-3, Mr. LaQue presented Mr. Tracy with an inscribed watch.

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information is complete, it is expected that much needed revisions in C 270 will be prepared.

Pursuing the difficult task of developing a standard test method for efflorescence, a new test method based on the extraction of soluble material from $\frac{1}{2}$ -in. set mortar bars was presented. The new method has certain advantages of simplicity and speed. However, its significance needs to be further established.

Manufactured Masonry Units (C-15)

Plastic and organic-type coatings for concrete masonry units is a new area to be covered by Committee C-15. A new subcommittee will consider the development of both specifications and methods of tests of products in this field. An effort will be made to add qualified representatives to the committee from industry, both producers and consumers.

In addition to the adoption as standard of a number of tentative revisions to the specifications for brick (C 62 and C 216), changes were approved for immediate adoption in the Methods of Sampling and Testing Concrete Masonry Units (C 140) including a note on the procedure of capping units.

Asbestos-Cement Products (C-17)

The chemical and mechanical properties of asbestos-cement pipe were explored in three papers presented at the meeting of Committee C-17. "The Behavior of Normal and Autoclave-Cured Asbestos-Cement Pipe Under Various Sulfate Conditions During Long-Term Field and Laboratory Tests" was the title of a paper presented by L. R. Blair, director of research, Johns-Manville Corp., and co-authored by Philip W. Manson, University of Minnesota. "Preliminary Research Results of Chemical Tests and Mechanical Properties of Asbestos-Cement Pipe" were reported by Paul Brennan and N. L. Nemerow, University of Syracuse. The third paper, presented by William Lerch, now retired from the Portland Cement Assn., discussed "The Mechanism of Sulfate Attack on Portland-Cement Paste." The subject of chemical stability of asbestos-cement pipe is undergoing very careful study in the committee at the present time.

Reports from the subcommittees responsible for standards for roofing and siding indicate that all present

standards are being reviewed for further refinement. Freezing-and-thawing tests, color stability, and water penetration tests are being studied. The development of a standard for a sandwich-type asbestos-cement board was given further review in the subcommittee dealing with flat and corrugated sheets.

Ceramic Whitewares and Related Products (C-21)

At the meeting of the Task Group on Nonplastics, six laboratories reported on a blend of silica with a particle size ranging between 50 per cent above and 50 per cent below 10 μ . These data will provide a basis for a recommended practice for the use of micro-mesh sieves in the 45 to 15 μ range for a single-phase system (work on a multiphase system will be undertaken in the future). A new interlaboratory study was initiated using a finer blend of nonplastic whose upper limit will be 5 μ . Three samples will be used: alumina, calcite, and flint. The Mine Safety Appliance particle size analyzer centrifuge technique and the centrifuge-hydrometer technique will be used. A parallel study of the same material will be made with the Coulter counter.

A new task group on graphite pipe has been formed. Its work will be primarily directed toward the development of specifications for graphite pipe for use in the chemical process industry.

Sorptive Mineral Materials (C-23)

Committee C-23 reported the publication of its first standard, a new Tentative Method for Sampling and Evaluation of Sorptive Mineral Products used as Floor Absorbents (C 431). Interlaboratory work is under way on

bulk density, water solubility, water breakdown, water absorption, and resistance to mechanical breakdown of sorptive mineral products. A literature search is being made to determine appropriate methods for abrasiveness, fire resistance, and slipperiness. A method for oil absorption of sorptive mineral products currently used by the Westinghouse Electric Corp., is under consideration.

Joint Sealants (C-24)

Until now, work in Committee C-24 has dealt with the polysulfide-base compounds, mostly because there were data in existence on these materials. The committee will now inaugurate programs dealing with all types of compounds, and those producers and consumers having an interest in the various materials are urged to present their recommendations to the committee.

The Subcommittee on Bulk Compounds is concentrating on the development of methods of tests that will be applicable to all types of compounds. These test methods will cover adhesion, accelerated aging, application rate and flow, and staining. A round-robin test program has been completed on the evaluation of a National Bureau of Standards test for staining. This test program will be repeated to obtain additional information leading to the preparation of a proposed method of test.

The Subcommittee on Preformed Shapes has completed an analysis on end-use criteria which will assist the group in the preparation of test methods and, ultimately, specifications.

Road and Paving Materials (D-4)

A permanent subcommittee on precision will be formed to assist all working subcommittees in the development of proper precision statements for all test methods. An ad hoc committee will prepare a standard on heating ovens used in ASTM test methods. The committee will relate its work to the existing Specification for Laboratory Ovens (E 145).

Further cooperative tests are needed before test methods can be prepared to cover the new cationic emulsions. A streamlining of the present Specification for Asphalt Cement (D 946) was accomplished in the reduction of the present nine penetration grades to five. This will eliminate certain penetration grades not in use in present-day construction.

Both specifications and methods of test are being prepared for reflective markers for highway purposes. The



MISS MARIE OUNAN, HEADQUARTERS REPRESENTATIVE AT BERMUDA CONFERENCE, BOARDS BUS IN ATLANTIC CITY.

Method of Testing Preformed Expansion Joint Fillers for Concrete (D 545) is being revised to conform with the new Specifications accepted in 1960 (D 1751 and D 1752).

Coke and Coal (D-5)

The determination of heating value of solid fuels using the adiabatic calorimeter will soon be proposed for publication by the Society. This method is being presented to ISO/TC 27 on Solid Mineral Fuels at their invitation. A need for improvements in the methods of sampling and analysis of coal for moisture content has been recognized with the establishment of projects to develop new procedures that will lead to standard methods. The mechanical sampling of coal and the preparation of samples for analysis are two new proposed methods that are expected to be completed this year. These methods represent six years of industrial study and careful analytical study of the resulting data.

The Subcommittee on Coal Classification has been reactivated in order to make some desirable revisions in the present coal specifications. A recent survey has indicated that the Specification on Gas and Coking Coals (D 166) may have outlived its usefulness.

The largest delegation to ISO/TC 27 on Solid Mineral Fuels was sponsored by Committee D-5 at the Sixth Plenary Session in London during the week of June 26. Each representative is an expert in a selected field so that the United States viewpoint was well represented.

Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses (D-8)

The use of nonbituminous synthetic materials for waterproofing and roofing purposes was discussed in Committee D-8. Definite interest was expressed in the development of standards for these materials even though the present scope of the committee is restricted to bituminous materials.

The Subcommittee on Industrial Pitches presented a second draft of a Method of Test for Determining the Quinoline Insoluble (C-1) Content of Tars, Tar Oils, and Pitches.

Paper and Paper Products (D-6)

The subcommittees on chemical and physical test methods are being organized as joint groups with the Technical Association of the Pulp and Paper Industry. This reorganization is intended to eliminate duplication of effort

in the development of paper test methods. Methods for mold resistance, qualitative content, thickness of paper and paper products, stretch of paper under tension, and specular gloss at 75 deg are being circulated for approval within the subcommittees.

The committee is actively participating in the work of the U. S. Advisory Group to ISO/TC 6 on Paper. This group is developing a U. S. opinion on the many paper methods and specifications under consideration by ISO.

Industrial Aromatic Hydrocarbons (D-16)

Methods for polymer content, aldehydes, and inhibitor content in styrene monomer and solubility of styrene polymer have been prepared. Four other styrene methods are under development.

The color of phthalic aldehyde in the molten state and after heating and the protocol solidification test are in the process of interlaboratory qualification tests. The tables for calculation of volume and weight of benzene, toluene, and paraxylene (D 1555) have been revised. Tables are being developed for mixed xylene ratios and for styrene. A new hydrometer method to determine the weight in pounds per U. S. gallon in air is being developed.

Interlaboratory data were reported on the current water solubility and permanganate oxidation number of nitrogen heterocycles.

The use of solidification-point cells for phthalic anhydride and naphthalene developed by the National Bureau of Standards is being written in ASTM form. Publication of the method of handling these cells is important in order to obtain the correct solidification point of the sample and prevent break-

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age of the cell during the heating and cooling cycles.

Naval Stores (D-17)

Committee D-17 has completed work on most of the traditional naval stores products, although some activity continues on rosin analysis. For these products, the main effort is to keep these standards up-to-date.

The committee is cooperating with the Tall Oil Division of the Pulp Chemicals Assn. in the development of standards for tall oil. Consideration is presently being given toward initiating work on specifications for tall oil fatty acids.

Soils for Engineering Purposes (D-18)

Nuclear methods for measuring the in-place density and moisture content of soils for construction control and foundation investigation will receive increased attention in Committee D-18 through a section organized for this purpose. The committee has already recognized this important development through the sponsorship of symposia held both at the 1960 and 1961 Annual Meetings.

A new method was approved for diamond core drilling which will be of particular interest to drilling contractors and suppliers of equipment as well as to engineers and organizations engaged in securing undisturbed samples which will provide information for design of foundations and similar engineering projects.



ONE IN A THOUSAND

This scene was typical of the more than 1000 meetings of technical committees and their subgroups. The group shown above is Subcommittee II-f on Petrography of Committee C-9 on Concrete and Concrete Aggregates. Subcommittee Chairman Katharine Mather is in the chair.

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A proposed method of test for the load capacity of batter pile frames will be circulated for subcommittee letter ballot. A method of test for determining the lateral load capacity of single vertical piles is under development.

Industrial Water (D-19)

Methods for sampling radioactive industrial water and for the determination of radiostrontium are near completion in Committee D-19. A method for determination of radiocobalt is under development. Also being prepared is a method of test for alpha particle radioactivity, which will complement the present methods for gamma radioactivity and beta particle radioactivity. A chapter on radioactive contamination in reactor cooling water is being written for inclusion in the next edition of the "Manual on Industrial Water and Industrial Waste Water." Work is under way on the development of specifications for "heavy water" and test methods for evaluating the specified properties.

Methods for flow measurement by the Parshall flume were approved for submittal to the Society, to be followed by methods for flow measurement by weirs now in preparation.

Methods of test for impurities in steam are being evaluated and should be completed within the coming year. An X-ray fluorescence method for the analysis of water-formed deposits is under study. Also being developed is a general scheme for analysis of water-formed deposits using preliminary qualitative investigations plus quantitative analysis by conventional chemical methods.

Plastics (D-20)

Committee D-20 has established a project to develop standards for vinyl chloride monomers and at the same time has set up a study group to investigate the whole matter of standards for monomers and to recommend a policy for the committee, having in mind that several other committees of the Society are concerned with monomers—ethylene, propylene, and butadiene in the petroleum committee; styrene and phenol in Committee D-16 on Industrial Aromatic Hydrocarbons. The committee also:

¶ Established a new Section on Acetal Resins in the Subcommittee on Thermoplastics.

¶ Established a new Section on Cements in the Subcommittee on Plastic Pipe and Fittings.

Mica Standards Presented to India

THE QUALITY OF mica can best be judged by eye. This is the basis for the ASTM Specification for Natural Muscovite Mica Based on Visual Quality. The physical embodiment of this standard is a master set of visual quality standards kept in a safe at ASTM Headquarters. Two additional master sets of these standards have been authenticated by a subgroup of Committee D-9 on Electrical Insulating Materials. One of these sets was prepared some time ago and is in use by the General Services Administration as a basis for grading mica for government procurement. A third set was prepared recently for the Government of India. India provides some 80 per cent of all the electronic grade mica used in this country. The request for these standards was made by the Indian Standards Institution on behalf of the Mica Export Promotion Council of the Government of India.

The official transmittal of the master set of visual quality standards and presentation of a scroll authenticating these standards took place at a special luncheon on June 30 at Atlantic City, where the Society was host to a number of distinguished guests. Present at the luncheon in addition to President Bates and the representatives of the Government of India were Miles N. Clair, president elect, and R. W. Seniff, vice-president of ASTM; A. C. Webber, ASTM vice-president elect; J. R. Townsend, president of the American Standards Assn., the agency in this country through which the request from India had been transmitted; H. W. Dailey of the ASA Staff; A. H. Scott, chairman of Committee D-9; Thomas Hazen, re-

cording secretary of Committee D-9; H. E. Brafman, chairman of the task group that prepared and authenticated the mica standards; W. M. Adams, president of Sprague Electric Co.; P. Esposito, Sprague Electric Co.; T. A. Marshall, Jr., ASTM executive secretary; R. E. Hess, ASTM technical secretary; and other members of the ASTM Staff.

Dr. Townsend, addressing the group, observed that the standards movement is growing and indicated that these visual standards are a token of the relationship between countries in the development and use of standards. American technology, he said, has been exported all over the world, and American engineering and textbooks are used everywhere. But, he added, American test equipment and machines are not being exported in this way. He urged stronger efforts in exporting not only technology but machinery and test equipment.

President Bates, in his remarks accompanying the presentation of the scroll, recalled that the mica in question is called muscovite, and this means literally "mica from Moscow." The name for this grade of mica was derived from an early use of this material by Russia, first for portholes in ships and later as windows in houses. He observed that the presentation of these mica standards to India emphasizes a growing international interdependence.

C. J. Stracey, representing the Government of India, expressed appreciation on behalf of his country to the Society and to the individuals who gave their time and effort to develop the standards.



PRESENTATION OF MICA STANDARDS

(Left to right) C. J. Stracey, representing the Minister, Embassy of India; A. Allan Bates, retiring ASTM President; and I. Subramanya, representing the Consul-General of India.

¶ Will cooperate with the Society of the Plastics Industry and the American Society of Illuminating Engineers to develop standard methods for light stability for indoor light diffusers.

¶ Approved seven new tentatives which were preprinted in the Annual Report.

Casein and Similar Protein Materials (D-25)

Interlaboratory results on viscosity of a 15 per cent solution of casein and an isolated soya protein solution were presented. Eight of the twelve laboratories reported results that compared very closely. In view of the considerable work previously done on viscosity, it was proposed that the method be circulated to the committee for approval.

Interlaboratory data on methods for determining the pH, viscosity, and adhesive strength of pigmented coatings were reviewed.

Revised test procedures for foreign matter content and foaming were discussed, and these methods will be presented to the entire committee for approval. The effect of humidity on sieve analysis was reviewed, and the present method will be rewritten, possibly including a brushing test. Further interlaboratory work was reported on methods for odor and insolubles. Test methods are also being developed for fat, bacteria, and mold count of casein and soya protein.

Halogenated Organic Solvents (D-26)

Committee D-26 formed a new Subcommittee on Drycleaning. Interest was evidenced by the fact that about 20 prospective members attended. A list of possible fields for study included a history of drycleaning, equipment, specifications and test methods, safety regulations and zoning codes, and detergent systems. Three task groups were formed: (1) to prepare a subcommittee scope, (2) to prepare solvent specifications, and (3) to study safety requirements, legislation, and zoning codes.

After much work and final resolution of problems connected with the section on general hazards, the committee has completed work on a Vapor Degreasing Manual. This manual will soon be submitted to ASTM for publication.

Electrical Insulating Liquids and Gases (D-27)

Expensive and irritating outages of electrical power transmission can occur from relatively simple failures of transformers, cables, and switching equipment. One likely cause for such failures

is the tendency for gas to evolve from apparatus in service, which can be explosive, given the right conditions. If the tendency of certain apparatus to evolve explosive gases could be anticipated through some measurement of materials properties, steps could be taken to prevent the occurrence. This problem has been tackled by the Subcommittee on Gases of Committee D-27, which has established a program to develop methods for evaluating gas evolution from apparatus in service.

Subcommittee N on Electrical Tests has completed a method for the dielectric strength of insulating liquids, using the so-called VDE electrodes developed in Germany, which is an improvement over the method previously available. The subcommittee is developing methods for determining dielectric strength properties of gases and small samples of synthetic liquid products, and also a method for electric stability of cable oils and for oxidation tendency of insulating oils using a continuous measurement of power factor. The Subcommittee on Chemical Tests is endeavoring to clarify the sulfur corrosion determination as outlined in Method D 1275 in view of a number of inquiries from companies having difficulty interpreting the results of the method. The subcommittee has completed a method for thermal stability of chlorinated organic liquids known as askarels.

Emission Spectroscopy (E-2)

Methods were approved, for publication as information only, covering emission spectrochemical analysis of indium and gallium. Methods are being developed to cover a number of additional materials, including zirconium, titanium, tungsten, columbium, molybdenum, beryllium, hafnium, precious metals, and various semiconductor materials.

A considerable number of the methods for emission spectrochemical analysis currently published as information only are to be cooperatively evaluated, and revised where necessary, for publication as tentative methods.

It was announced that Part V of the Index to the Literature, covering the period 1955-1960, is now ready for publication.

Chemical Analysis of Metals (E-3)

Increasing use of the refractory metals such as columbium, tantalum, molybdenum, tungsten, and rhenium is making necessary the development of standardized methods for chemical analysis of these metals and their alloys. As a result, a new Division R on Refractory Metals has been organized in

Committee Activities

Committee E-3, with most present activity being on methods for analysis of columbium. It is believed that many of the columbium methods may also be found suitable for analysis of tantalum.

Methods for analysis of ferrocolumbium are near completion.

Metallography (E-4)

During the past two years, Subcommittee IX of Committee E-4 has accomplished intensive work on rating the inclusion contents of steel. It was found that the Recommended Practice for Determining the Inclusion Content of Steel (E 45 - 51) needed revision in order to reflect up-to-date practice. This has resulted in the inclusion of the SAE rating chart for oxides and silicates, in addition to the previous Jernkontoret chart, in the 1960 revision (E 45 - 60 T). A further extension is planned to cover the rating of inclusions in vacuum melted and special quality steels.

As a result of the general acceptance of the Tentative Methods for Estimating the Average Grain Size of Metals (E 112), these methods have been adopted as standard. The corresponding withdrawal of the earlier grain size methods, E 19, E 79, E 89, and E 91, is under way (see p. 638).

The Recommended Practice for Identification of Crystalline Materials by the Hanawalt X-ray Diffraction Method (E 43) has been recognized as obsolete for some years. The Joint Committee on Chemical Analysis by Powder Diffraction Methods has been working on a document to supersede it. Committee E-4 is considering withdrawing E 43.

Committee E-4 has given final approval to a Tentative Recommended Practice for Resistometric (or EMF) Analysis of Metallic Materials and will shortly propose to the Society that this new document be approved for ASTM publication.

Methods of Testing Building Constructions (E-6)

Performance criteria were discussed at some length in the meeting of Committee E-6. Owing to the wide divergence of views expressed it was felt advisable to conduct a symposium or panel discussion on the subject at a future meeting of the committee.

Proposed standards that are expected to be ready for acceptance by the committee during the next year include a static test for water penetration of panels of brickwork, a method of test

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for completed floors and flat roofs, and a recommended practice for achieving optimum durability of materials incorporated in buildings.

The first of several test methods for determining the properties of windows and window assemblies is expected to be completed during the year. Test methods for each of the essential properties of windows will be prepared. The Recommended Practice for Laboratory Measurement of Air-Borne Sound Transmission Loss of Building Floor and Walls (E 90) was revised in accordance with recommendations in the 1961 Annual Report of the committee. Of especial interest is the fact that this method is now similar to that adopted by the ISO. A new test method in this field will be prepared covering methods for checking the transmission of impact noises such as footsteps, etc.

Nondestructive Testing (E-7)

Committee E-7 reported that two new series of reference radiographs are in the final stages of preparation. A series of reference radiographs for steel castings, applicable to section thicknesses of 2 to 4½ in., has been agreed upon and is being prepared for consideration by the committee. Another task group has prepared a series of reference radiographs for investment steel castings for aerospace applications which will be referred to Committee E-7 and the Society for publication.

Other activities under way include very important revisions to the Recommended Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks (E 127), which reflect the up-to-date use of the reference blocks in industry. Also reference photographs for the wet magnetic particle test and for fluorescent penetrant tests are being collected as the basis for ASTM documents.

Committee E-7 will sponsor a symposium during the 1962 ASTM West Coast National Meeting on late developments in nondestructive testing techniques and their effect on design.

Radioisotopes and Radiation Effects (E-10)

In July, 1960, Committee E-10 took steps to organize a Special Study Group on Problems of Space Radiation, Including Correlation of Testing Methods with Anticipated Space Environment. The objectives were to procure the best available answers to the following questions:

1. What radiation exists in space

and what do we know about it qualitatively and quantitatively?

2. How can we extrapolate our knowledge of nuclear fission fragment damage and other data to space radiation effects on materials?

3. What program can be suggested for future work in the light of materials being used now and contemplated for future use?

The study group later organized four subgroups in the following areas:

- I. Characterization of Space Radiation (Naturally-Occurring).
- II. Radiation Effects on Materials.
- III. Facilities for Testing and Desirable Experimental Programs.
- IV. Sources of Information and Liaison.

The study committee reported to Committee E-10 at the Annual Meeting. Committee E-10 accepted the report, agreed to give full consideration to its contents, and discharged the study group with commendation for a very informative report. The Society is considering publication of the report, since it appears to consolidate all the various aspects of the space environment in one technical report.

Quality Control of Materials (E-11)

Recommended practices for use of the terms precision and accuracy as applied to measurement of a property of material and for dealing with outlying observations were both approved by Committee E-11 for recommendation to the Society as tentative. The concepts expressed in both these recommended practices will be useful to all the committees of the Society in establishing their own practices for dealing with these aspects for the handling of data.

Another project quite far along is the

development of a practice for interlaboratory evaluation of a test method. This practice, when approved by the committee, is to be published by the Society as a manual. It is hoped that this will be completed and available within the coming year.

Applied Statistics in ASTM Work

The powerful tool of statistics is increasingly being brought to bear on problems of materials testing. Most committees have subcommittees or other groups concerned with applied statistics. This has resulted in a large number of standards and tentatives being written covering the sampling of various materials, the defining of precision and accuracy as it applies to test methods, and the establishment of practices for interlaboratory evaluation of test methods. To coordinate these many activities in different committees and to provide a meeting place for all the committees to discuss statistics, Committee E-11 on Quality Control of Materials has long had an active subcommittee on ASTM problems, with representatives from all the interested committees of the Society.

This subcommittee, under the chairmanship of C. A. Bicking of the Carborundum Co., sponsored a special session at the Annual Meeting to foster intercommittee discussion of the problems of conducting interlaboratory studies of test methods and of defining the terms precision and accuracy. Grant Wernimont, Eastman Kodak Co., told of the present status of the Proposed Recommended Practice for Conducting an Interlaboratory Study of a Test Method, which has been in preparation for some time in Committee E-11. Several years ago, John Mandell, National Bureau of Standards, developed a theoretical model for the



EXHIBIT OF ASTM PUBLICATIONS WAS A POPULAR GATHERING PLACE

statistics involved, considering testing as a process. This model is the basis for the Recommended Practice for Interlaboratory Testing of Paper and Paper Products (D 1749). Dr. Wernimont had added to the statistics of Dr. Mandell and had developed a draft of a recommended practice which started with the simple case of a few materials and laboratories, developing step by step through the statistical reasoning needed to handle n materials and n laboratories. It is expected that this general recommended practice will be published by the Society as a manual something like the present Manual on Quality Control of Materials (STP 15c).

R. B. Murphy of Bell Telephone Laboratories explained the reasoning behind the proposed tentative recommended practice for use of the terms precision and accuracy as applied to a measurement of a property of a material. He explained that the term "accuracy" is considered to include the concepts of precision or small random error as well as freedom from bias. The term "precision" has to do with the closeness of individual measurements to each other; the more closely bunched they are, the higher the precision.

This concept of accuracy, while widely held, differs from that normally used by

the chemist. The chemist is accustomed to considering bias and accuracy as synonymous terms. It should be pointed out, however, that the chemists in ASTM, as represented on Committee E-15 on Analysis and Testing of Industrial Chemicals, have adopted the concept of accuracy as expressed in the proposed practice, expressing the meaning of accuracy as follows: "Although the term 'accuracy' is frequently used in chemical work to express the agreement between an experimentally determined mean value and the true or accepted value, in ASTM usage this term assumes a broader meaning, combining the concepts of both precision and bias."

Dr. Murphy warned of pitfalls in using the terms "repeatability" and "reproducibility," so prevalent in many ASTM committees. He pointed out that it is not always clear from the context in which these terms are used which causes have been included in these terms. Usually, but not always, "repeatability" appears to mean single-laboratory, multioperator-machine-day precision, and "reproducibility" appears to mean multi-laboratory-operator-machine-day precision. The system of causes referred to by each of these terms should always be stated when the terms are used.

Committee Activities

Materials for Electron Tubes and Semiconductor Devices (F-1)

At the Annual Meeting Committee F-1 reported that it:

- ¶ Is developing a glossary of terms.
- ¶ Has recommended that the Society study standardization needs in the field of microelectronics.
- ¶ Has developed a Recommended Practice for Temperature Measurement of Thermionic Emitters and is making progress in the measurement of airborne contaminants and surface contamination and purity requirements for solvents and other liquids used for cleaning.
- ¶ Is working with ASESA and the Signal Corps in coordinating ASTM standards with military specifications.
- ¶ Is making progress in the measurement of dislocations in silicon and for orienting single crystals; also in the measurement of lifetime of semiconductors.
- ¶ Has established a task group on evaluation of epitaxially grown layers.

Society Accepts New Tentatives and Standards

At the 64th Annual Meeting the Society accepted 150 new tentatives and 25 new standards, the titles and designations of which are given below. Other actions taken at the meeting in regard to standards are summarized in the table on p. 663.

The numerical designations of the technical committees responsible for these tentatives are shown after the boldface headings.

Steel (A-1)

Method and Specification for Magnetic Particle Inspection of Large Crankshaft Forgings (A 456 - 61 T)

Specifications for:

- Centrifugally Cast Austenitic Steel Pipe for High-Temperature Service (A 451 - 61 T) (Joint with A-10)
- Centrifugally Cast Austenitic Cold-Wrought Pipe for High-Temperature Service (A 452 - 61 T) (Joint with A-10)
- High-Strength, High-Temperature Bolt- ing Materials with Expansion Coefficients Comparable to Austenitic Steels (A 453 - 61 T) (Joint with A-10)
- Steel Conveyor Chain (A 454 - 61 T)
- High-Tensile-Strength Carbon-Manganese Steel Plates for Unfired Pressure Vessels (A 455 - 61 T)

Corrosion of Iron and Steel (A-5)

Specifications for:

- Zinc-Coated Flat Steel Armoring Tape (A 459 - 61 T)
- Copper Covered Steel Wire Strand (A 460 - 61 T)

Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys (A-10)

Specifications for:

- Centrifugally Cast Austenitic Steel Pipe for High-Temperature Service (A 452 - 61 T) (Joint with A-1)

- Centrifugally Cast Austenitic Cold-Wrought Pipe for High-Temperature Service (A 452 - 61 T) (Joint with A-1)
- High-Strength, High-Temperature Bolt- ing Materials with Expansion Coefficients Comparable to Austenitic Steels (A 453 - 61 T) (Joint with A-1)
- Hot and Cold-Worked Alloy Steel Plate, Sheet, and Strip for High Strength at Elevated Temperatures (A 457 - 61 T)
- Hot and Cold-Worked Alloy Steel Bars for High Strength at Elevated Temperatures (A 458 - 61 T)

Corrosion of Non-ferrous Metals and Alloys (B-3)

Method of Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (Cass Test) (B 368 - 61 T)

Copper and Copper Alloys, Cast and Wrought (B-5)

Specifications for:

- Copper-Nickel Alloy Castings (B 369 - 61 T)
- Copper Sheet and Strip for Building Construction (B 370 - 61 T)
- Copper-Zinc-Silicon Alloy Rod (B 371 - 61 T)
- Seamless Copper and Copper-Alloy Rectangular Waveguide Tube (B 372 - 61 T)

Light Metals and Alloys, Cast and Wrought (B-7)

Specifications for Aluminum Foil for Capacitors (B 373 - 61 T)

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Electrodeposited Metallic Coatings and Related Finishes (B-8)

Definitions of Terms Relating to Electroplating (B 374 - 61 T)

Specification for Electrodeposited Coatings of Multi-layer Nickel Plus Chromium on Steel (B 375 - 61 T)

Metal Powders and Metal Powder Products (B-9)

Method of Test for:

Density of Sintered Metal Friction Materials (B 376 - 61 T)

Transverse Rupture Strength of Sintered Metal Friction Materials (B 378 - 61 T)

Specification for Steel-Backed Metal Powder Bearing and Bushing Alloys (B 377 - 61 T)

Cement (C-1)

Specifications for Processing Additions for Use in the Manufacture of Portland Cement (C 465 - 61 T)

Chemical-Resistant Mortars (C-3)

Specification for Chemically Setting Silicate-Type Chemical-Resistant Mortars (C 466 - 61 T)

Refractories (C-8)

Classification of:

Mullite Refractories (C 467 - 61 T)
Refractory Granular Dolomite (C 468 - 61 T)

Concrete and Concrete Aggregates (C-9)

Method of Test for:

Static Young's Modulus of Elasticity and Poisson's Ratio in Compression of Cylindrical Concrete Specimens (C 469 - 61 T)

Specification for Single-Use Molds for Forming 6 by 12-in. Concrete Compression Test Cylinders (C 470 - 61 T)

Gypsum (C-11)

Methods of:

Chemical Analysis of Gypsum and Gypsum Products (C 471 - 61 T)

Physical Testing of Gypsum Plasters and Gypsum Concrete (C 472 - 61 T)

Physical Testing of Gypsum Board Products and Gypsum Partition Tile or Block (C 473 - 61 T)

Testing Joint Treatment Materials for Gypsum Wallboard Construction (C 474 - 61 T)

Specifications for Joint Treatment Materials for Gypsum Wallboard Construction (C 475 - 61 T)

Mortars for Unit Masonry (C-12)

Specifications for Mortar and Grout for Reinforced Masonry (C 476 - 61 T)

Concrete Pipe (C-13)

Specifications for:

Cast-in-Place Nonreinforced Concrete Irrigation Closed Conduit (C 477 - 61 T)
Precast Reinforced Concrete Manhole Risers and Tops (C 478 - 61 T)

Structural Sandwich Constructions (C-19)

Method of Test for:

Flexure-Creep of Sandwich Constructions (C 480 - 61 T)

Laboratory Aging of Sandwich Constructions (C 481 - 61 T)

Ceramic Whitewares and Related Products (C-21)

Method of Test for:

Bond Strength of Glazed Interior Ceramic Wall Tile in Portland Cement Installations (C 482 - 61 T)

Electrical Resistance of Conductive Ceramic Tile (C 483 - 61 T)

Thermal Shock Resistance of Glazed Ceramic Tile (C 484 - 61 T)

Method for Measuring Warpage of Ceramic Tile (C 485 - 61 T)

Porcelain Enamel (C-22)

Method of Test for Spalling Resistance of Porcelain Enameled Aluminum (C 486 - 61 T)

Paint, Varnish, Lacquer, and Related Products (D-1)

Specifications for:

Distilled Coconut Fatty Acids (D 1841 - 61 T)

Distilled Corn Fatty Acids (D 1842 - 61 T)

Asbestos-Cement Shingle Blanks To Be Used as Panels in Weathering Tests of Latex and Emulsion Paints (D 1911 - 61 T)

Fractionated and Distilled Cottonseed Fatty Acids (D 1843 - 61 T)

Methods for:

Chemical Analysis of Basic Lead Silico-Chromate (D 1844 - 61 T)

Chemical Analysis of Strontium Chromate Pigment (D 1845 - 61 T)

Method of Test for:

Water-Soluble Matter in Iron Oxide Pigments by Specific Resistance Method (D 1846 - 61 T)

Total Chlorine Content of Epoxy Resins (D 1847 - 61 T)

Package Stability of Latex Paint (D 1849 - 61 T)

Specific Gravity of Drying Oils, Varnishes, Resins, and Related Materials at 25/25 C (D 1963 - 61 T)

Saponification Value of Drying Oils and Fatty Acids (D 1962 - 61 T)

Unsaponifiable Matter in Drying Oils and Fatty Acids (D 1965 - 61 T)

Iodine Value of Drying Oils and Fatty Acids (D 1959 - 61 T)

Loss on Heating of Drying Oils (D 1960 - 61 T)

Foots in Raw Linseed Oil (D 1954 - 61 T)

Quantitative Determination of Break in Drying Oils (D 1952 - 61 T)

Acetone Tolerance of Heat-Bodied Drying Oils (D 1950 - 61 T)

Gel Time of Drying Oils (D 1955 - 61 T)

Tung Oil Quality (D 1964 - 61 T)

Drying Properties of Drying Oils (D 1953 - 61 T)

Ash in Drying Oils and Fatty Acids (D 1951 - 61 T)

Matter Insoluble in Chloroform in Oil-cica Oil (D 1958 - 61 T)

Hydroxyl Value of Fatty Oils and Acids (D 1957 - 61 T)

Heat Bodying Rate of Drying Oils (D 1956 - 61 T)

Maleic Diene Value of Drying Oils (D 1961 - 61 T)

Titer of Fatty Acids (D 1982 - 61 T)

Acid Value of Fatty Acids (D 1980 - 61 T)

Color After Heating of Fatty Acids (D 1981 - 61 T)

Method of Reporting Paint Film Failures Characteristic of Exterior Latex Paints (D 1848 - 61 T)

Petroleum Products and Lubricants (D-2)

Method of Test for:

Roll Stability of Lubricating Grease (D 1831 - 61 T)

Oxidation Stability of Paraffin Wax (Per-oxide Method) (D 1832 - 61 T)

Odor of Petroleum Wax (D 1833 - 61 T)

20-deg Specular Gloss of Waxed Paper (D 1834 - 61 T)

Volatility of Liquefied Petroleum (LP) Gases (D 1837 - 61 T)

Copper Strip Corrosion by Liquefied Petroleum (LP) Gases (D 1838 - 61 T)

Amyl Nitrate in Diesel Fuels (D 1839 - 61 T)

Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry (D 1840 - 61 T)

Specifications for:

Liquefied Petroleum (LP) Gases (D 1835 - 61 T)

Commercial Hexanes (D 1836 - 61 T)

Road and Paving Materials (D-4)

Specifications for:

Concrete Joint Sealer, Cold-Application Type (D 1850 - 61 T)

Jet-Fuel-Resistant Concrete Joint Sealer, Cold-Application Elastic Type (D 1852 - 61 T)

Jet-Fuel-Resistant Concrete Joint Sealer, Hot-Poured Elastic Type (D 1854 - 61 T)

Methods of Testing:

Concrete Joint Sealers, Cold-Application Type (D 1851 - 61 T)

Jet-Fuel-Resistant Joint Sealer for Concrete, Cold-Application Elastic Type (D 1853 - 61 T)

Jet-Fuel-Resistant Concrete Joint Sealer, Hot-Poured Elastic Type (D 1855 - 61 T)

Method of Test for Recovery of Asphalt from Solution by Abson Method (D 1856 - 61 T)

Method of Test for Recovery of Asphalt from Solution by Abson Method (D 1856 - 61 T)

Coal and Coke (D-5)

Method of Test for Fusibility of Coal Ash (D 1857 - 61 T)

Wood (D-7)

Specification for:

Creosote-Petroleum Solution (D 1858 - 61 T)

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Petroleum for Blending with Creosote (D 1859 - 61 T)

Method of Test for Moisture and Creosote-Type Preservative in Wood (D 1860 - 61 T)

Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses (D-8)

Specifications for:

Homogeneous Bituminized Fiber Drain and Sewer Pipe (D 1861 - 61 T)

Laminated-Wall Bituminized Fiber Drain and Sewer Pipe (D 1862 - 61 T)

Mineral Aggregate for Use on Built-up Roofs (D 1863 - 61 T)

Method of Test for:

Moisture in Mineral Aggregate for Use on Built-up Roofs (D 1864 - 61 T)

Hardness of Mineral Aggregate for Use on Built-up Roofs (D 1865 - 61 T)

Translucency of Mineral Aggregate for Use on Built-up Roofs (D 1866 - 61 T)

Electrical Insulating Materials (D-9)

Specifications for Copper-Clad Thermosetting Laminates for Printed Wiring (D 1867 - 61 T)

Method for Corona Measurement (D 1868 - 61 T)

Rubber and Rubber-Like Materials (D-11)

Specifications for Rubber Rings for Asbestos-Cement Pipe (D 1869 - 61 T)

Method of Test for:

Elevated Temperature Aging Using a Tubular Oven (D 1870 - 61 T) (Joint with D-20)

Adhesion of Vulcanized Rubber to Single-Strand Wire (D 1871 - 61 T)

Free 2-Mercaptobenzothiazole in Benzothiazyl Disulfide Rubber Vulcanization Acceleration (D 1872 - 61 T)

Total 2-Mercaptobenzothiazole in Commercial Benzothiazyl Disulfide Rubber Vulcanization Accelerator (D 1873 - 61 T)

Textile Materials (D-13)

Method of Test for:

Diameter of Wool and Mohair Fibers by Microprojection (D 2130 - 61)

Dimensional Change in Woven or Knitted Textiles (Excluding Wool) (D 1905 - 61 T)

Estimation of Effective Gage Lengths in Single Fibers Testing (D 1906 - 61 T)

Yarn Number (Skein Method) (D 1907 - 61 T)

Yarn Severance in Woven Fabrics (D 1908 - 61 T)

Estimating Maturity and Weight per Unit Length of Cotton Fibers by the Caustic Method (D 2480 - 61 T)

pH of Aqueous Extracts of Wool and Similar Animal Fibers (D 2165 - 61 T)

Rapid Estimation of Staple Length of Wool Top (D 2142 - 61 T)

Colorfastness of Zippers to Laundering (D 2051 - 61 T)

Colorfastness of Zipper Stringers to Dry Cleaning (D 2052 - 61 T)

Colorfastness of Zippers to Light (D 2053 - 61 T)

Colorfastness of Zipper Tapes to Crocking (D 2054 - 61 T)

Colorfastness of Zipper Tapes to Perspiration (D 2055 - 61 T)

Resistance of Finish of Zippers to Dry Abrasion (D 2056 - 61 T)

Durability of Finish of Zippers to Laundering (D 2057 - 61 T)

Durability of Finish of Zippers to Dry Cleaning (D 2058 - 61 T)

Resistance of Zippers to Salt Fog (D 2059 - 61 T)

Measuring Zippers (D 2060 - 61 T)

Strength Tests of Zippers (D 2061 - 61 T)

Operability of Zippers (D 2062 - 61 T)

Moisture Content and Moisture Regain of Lint and Seed Cotton (Oven Method) (D 2495 - 61 T)

Definitions of Terms Relating to Zippers (D 2050 - 61 T)

Listing of Commercial Moisture Regains for Textile Fibers (D 1909 - 61 T)

Recommended Practice for Establishment of Standard Moisture Content for Wool and Its Products (D 2118 - 61 T)

Adhesives (D-14)

Specification for Water- or Solvent-Soluble Liquid Adhesives for Automatic Machine Sealing of Top Flaps of Fiberboard Shipping Cases (D 1874 - 61 T)

Method of Test for:

Density of Adhesives in Fluid Form (D 1875 - 61 T)

Peel Resistance of Adhesives (T-Peel Test) (D 1876 - 61 T)

Permanence of Adhesive-Bonded Joints in Plywood Under Mold Conditions (D 1877 - 61 T)

Pressure-Sensitive Tack of Adhesives (D 1878 - 61 T)

New Tentatives and Standards

Recommended Practice for Exposure of Adhesive Specimens to High-Energy Radiation (D 1879 - 61 T)

Engine Antifreezes (D-15)

Recommended Practice for Selection of Engine Antifreezes for Use in Automotive Cooling Systems, Ethylene Glycol and Methanol Types (D 1880 - 61 T)

Method of Glassware Test for Foaming Tendencies of Engine Antifreezes (D 1881 - 61 T)

Method of Test for Effect of Antifreeze Solutions on Organic Finishes for Automotive Vehicles (D 1882 - 61 T)

Soils for Engineering Purposes (D-18)

Method of Test for Bearing Ratio of Laboratory-Compacted Soils (D 1883 - 61 T)

Industrial Water (D-19)

Methods of Test for:

Acidity and Alkalinity of Industrial Water (D 1884 - 61 T)

Chloride Ion in High-Purity Industrial Water (D 1885 - 61 T)

Nickel in Industrial Water (D 1886 - 61 T)

Sodium in High-Purity Industrial Water by Flame Photometry (D 1887 - 61 T)

Suspended and Dissolved Solids in Industrial Water (D 1888 - 61 T)

Turbidity of Industrial Water (D 1889 - 61 T)

Hexane-Extractable Matter in Industrial Waste Water (D 1891 - 61 T)

Method for:

Measurement of Beta Particle Radioactivity of Industrial Water and Industrial Waste Water (D 1890 - 61 T)

Plastics (D-20)

Recommended Practice for:

Transfer Molding of Thermosetting Materials (D 1896 - 61 T)

Injection Molding of Specimens of Polystyrene Molding and Extrusion Materials (D 1897 - 61 T)

Sampling of Plastics (D 1898 - 61 T)

SUMMARY OF ACTIONS TAKEN AT 1961 ANNUAL MEETING AFFECTING STANDARDS AND TENTATIVES.

	New Standards and Existing Tentatives Adopted as Standards	Standards in Which Revisions Will Be Adopted	New Tentatives	Revisions of Standards to Tentatives	Tentative Revisions of Standards	Tentatives Revised	Standards and Tentatives Withdrawn
A. Ferrous Metals.....	12	17	10	1	...	65	3
B. Non-ferrous Metals.....	34	37	8	...	...	6	1
C. Cement, Lime, Gypsum, Concrete, and Clay Products.....	21	20	18	6	13	29	2
D. Paints, Petroleum Products, Bituminous Materials, Paper, Textiles, Plastics, Rubber, Soap, Water, etc.	90	48	100	11	8	50	12
E. Miscellaneous Subjects, Testing, etc.	18	3	10	...	2	3	...
F. Electronic Materials.....	...	...	4	...	...	4	...
Total.....	175	125	150	18	23	157	18

64th Annual Meeting

Specification for Styrene-Butadiene Molding and Extrusion Materials (D 1892 - 61 T)

Method of Test for:

Elevated Temperature Aging Using a Tubular Oven (D 1879 - 61 T) (Joint with D-11)

Blocking of Plastic Film (D 1893 - 61 T)
Coefficients of Friction of Plastic Film (D 1894 - 61 T)

Apparent Density, Bulk Factor, and Pourability of Plastic Materials (D 1895 - 61 T)

Methods of Atmospheric Sampling and Analysis (D-22)

Method of Test for Mass Concentration of Particulate Matter in the Atmosphere (Continuous-Measurement Light-Scattering Method) (D 1899 - 61 T)

Carbon Black (D-24)

Method for Sampling Bulk Shipments of Carbon Black (D 1900 - 61 T)

Halogenated Organic Solvents (D-26)

Method of Test for Relative Evaporation Time of Halogenated Hydrocarbons and Their Admixtures (D 1901 - 61 T)

Electrical Insulating Liquids and Gases (D-27)

Method of Test for:

Approximate Acidity and Polar Contamination in Used Mineral Transformer Oil by Spot Tests (D 1902 - 61 T)

Coefficient of Thermal Expansion of Electrical Insulating Liquids of Petroleum Origin, and Askarels (D 1903 - 61 T)

Oxidation Characteristics of Mineral Transformer Oils (D 1904 - 61 T)

Fire Tests of Materials and Construction (E-5)

Definition of Terms Relating to Fire Tests of Building Construction and Materials (E 176 - 61 T)

Radioisotopes and Radiation Effects (E-10)

General Methods for Analysis of Radioisotopes (E 181 - 61 T)

Methods for Analysis of Phosphorus-32 (E 182 - 61 T)

Recommended Practice for:

Determining Changes in Chemical Reactivity of Inorganic Materials Exposed to High-Energy Radiation (E 183 - 61 T)

Effect of High-Energy Radiation on the Tensile and Impact Properties of Metallic Materials (E 184 - 61 T)

Surveillance Tests on Structural Materials in Nuclear Reactors (E 185 - 61 T)

Quality Control of Materials (E-11)

Recommended Practice for:

Use of the Terms Precision and Accuracy as Applied to Measurement of a Property of a Material (E 177 - 61 T)

Dealing with Outlying Observations (E 178 - 61 T)

Appearance (E-12)

Recommended Practice for Selection of Geometric Conditions for Measurement of Reflectance and Transmittance (E 179 - 61 T)

Analysis and Testing of Industrial Chemicals (E-15)

Recommended Practice for Developing Precision Data on ASTM Methods for Analysis and Testing of Industrial Chemicals (E 180 - 61 T)

Materials for Electron Tubes and Semiconductor Devices (F-1)

Recommended Practice for Making and Testing Reference Glass-Metal Bead-Seal (F 14 - 61 T)

Specifications for Iron-Nickel-Cobalt Sealing Alloy (F 15 - 61 T)

Methods for Measuring Diameter or Thickness of Wire and Ribbon for Electronic Devices and Lamps (F 16 - 61 T)

Flexible Barrier Materials (F-2)

Definition of Terms Relating to Flexible Barrier Materials (F 17 - 61 T)

Joint Committee on Leather

Method of Test for Cold-Crack Resistance of Upholstery Leather (D 1912 - 61 T)

Annual Meeting Papers Still Available

Some of the papers that were not preprinted for the 1961 Annual Meeting were mimeographed primarily for the use of those interested in presenting discussion. A limited number of these are available from ASTM Headquarters at 50 cents each. There is a minimum charge of \$1.00 for any order. Please include paper number (shown in parentheses) with order.

Some Consequences of Excess Oxygen in UO_2 —J. A. L. Robertson (105)

Fission Fragment Tracks in UO_2 —T. S. Noggle and J. O. Steigler (105c)

Study of the Factors Controlling the Release of Xe^{133} from Bulk UO_2 —D. F. Toner and J. L. Scott (105e)

In-Pile Release of Fission Products in UO_2 —J. B. Melehan and F. A. Rough (105f)

The Continuous Release of Fission Gas from UO_2 During Irradiation—R. M. Carroll (105g)

Sintering Characteristics in a Radiation Environment—E. A. Aitken (105d)

Mechanism of Irradiation Damage in Uranium Monocarbide—D. G. Freas, A. E. Austin, and F. A. Rough (105i)

Hydrolysis of Beryllia—C. C. Browne (105k)

The Irradiation and Examination of a PuO_2 - UO_2 Fast Reactor Oxide Fuel—J. N. Siltanen, J. M. Gerhart, and J. S. Cochran (105l)

Liquid Drop Collisions—Olive Engel (93b)

Erosion by Liquid Impact—S. M. DeCorso and R. E. Kothmann (93d)

Dynamic Loading Machine and Results of Preliminary Small-Scale Footing Tests—R. W. Cunney and R. C. Sloan (96e)

Bearing Capacities of Dynamically Loaded Footings—S. Shenkman and K. E. McKee (96f)

Facilities for Dynamic Testing of Soils—G. K. Sinnamon and H. M. Newmark (96g)

The Damping Capacity of Some Granular Soils—G. F. Weissmann and R. R. Hart (96h)

A Nomographic Procedure for the Detection of Suspect Unconfined Compressive Strength Values in a Series of Soil-Additive Strength Determinations—H. T.

David, D. T. Davidson, and C. A. O'Flaherty (94)

Immediate Core Volume by Presaturation—L. E. Santucci and R. J. Schmidt (109)

Air Permeability of Asphalt Concrete—T. C. Hein and R. J. Schmidt (110)

The Rheology of Asphalt-Filler Systems as Shown by the Microviscometer—R. S. Winniford (114)

Investigation of Concrete Materials for a Major Project in Western Canada—G. C. Price (97)

Improved Adiabatic Calorimeter for Concrete—David Pirtz (98)

Strain Distribution in Compressively Loaded Concrete Specimens—J. R. Keeton (101b)

A Fatigue Test for Printed Wiring Boards and Through Connections—G. R. Gohn and A. Fox (72a)

Stress-Relaxation—Some New Test Methods for the Determination of This Mechanical Property Either in Tension or in Compression—G. R. Gohn and A. Fox (88a)

The following late preprints (prices as shown) have also become available:

A Study of the Accumulation of Fatigue Damage in Steel—W. H. Erickson and C. E. Work (71), 30 cents.

Effect of Oleophobic Films on Fatigue Crack Propagation—W. L. Holshouser and H. P. Utech (72), 30 cents.

Compression and Buckling Characteristics of Annealed and Aged Inconel 718 Nickel-Chromium Alloy at Temperatures up to 1400 F (81b), 30 cents.

A Study of Artificial Soils—E. T. Selig and R. D. Rowe (95), 50 cents.

Testing Uniformity of Large Batches of Concrete—D. L. Bloem, R. D. Gaynor, and J. R. Wilson (103), 50 cents.

Materials Research & Standards

MATERIALS SCIENCES

Highlights of Division Council Meeting

THE COUNCIL of the Division of Materials Sciences met on Tuesday, June 27, at the Annual Meeting. The first order of business was the formal adoption of the by-laws which had been submitted to letter ballot of the council before the meeting. After several modifications, including the deletions of the words "basic" and "fundamental," thereby broadening the scope

to include not only fundamental properties but also macroscopic behavior of materials, the scope was approved to read as follows:

The promotion of knowledge of the nature of materials. To this end, the Division shall encourage and provide for the exchange and dissemination of knowledge through articles, papers, symposia, conferences, and by any other means that may be considered appropriate and effective.

The Division will be concerned broadly with the nature and origin of properties of materials, that is, the relation of these

properties to their structure and will give special attention to matters common to more than one material or class of materials. Generally the Division will be concerned with specific materials only to the extent that their properties illustrate fundamental principles.

Division Membership

The by-laws provide for membership in the Division on application to the Division Executive Committee by any member of the Society. Individual members are eligible, and one person may be designated to represent an organizational membership in the Division. This provision will be voted on by the Board of Directors in September.

Symposium Programs

A report on the Division-sponsored Symposium on Major Effects of Minor Constituents on the Properties of Materials, presented at the 64th Annual Meeting, appears on p. 648.

The Division will sponsor symposia both at the Annual Meeting in New York in June, 1962, and the Pacific Area National Meeting in Los Angeles in October, 1962. The subject for the Annual Meeting in New York is "Stress-Strain-Time-Temperature Phenomena in Materials." The chairman of the Symposium Committee is A. C. Webber, with co-workers B. J. Lazan, A. G. H. Dietz, and L. L. Wyman. Plans are to invite five papers to be presented in two sessions, probably ending with a panel discussion. Three of the papers will treat three major categories of materials—metals, ceramics, plastics—with two additional papers covering the temperature and time aspects of materials properties.

The subject chosen for the Los Angeles meeting in October is on properties of surfaces. The chairman of the Symposium Committee is W. L. Fink.

Materials Education

Discussion in the council indicated concern for the two major aspects of this problem—industry needs for adequately trained technical staff and the problem of matching university curricula to industry needs. On the basis of the discussion, the Division Executive Committee will establish a committee on education to deal with this problem.

Inter-Society Cooperation

Discussion in the council revealed a strong feeling that the Division should establish close working relations with other societies dealing with materials sciences.

Publication Policies

As the Division has embarked upon a

Richard H. Krock to Receive Second ASTM Doctoral Fellowship

RICHARD H. KROCK has been selected by the Massachusetts Institute of Technology to receive the second ASTM Doctoral Fellowship, established by the ASTM Board of Directors for the promotion of the knowledge of materials. The \$6500 award provides \$5000 for the fellow and \$1500 for the Institute.

Mr. Krock did his undergraduate work at MIT, where he received a bachelor's degree in metallurgy in June, 1959. His major field of interest was in physical metallurgy. He was a dean's list student and is a member of Pi Lambda Upsilon, Tau Beta Pi, and Sigma Xi honorary societies.

Mr. Krock entered graduate school at MIT in 1959 and was awarded an Owens Corning Fibreglas Corp. fellowship. His graduate curriculum broadened from metallurgy to materials science, and he took courses in ceramics and polymers in addition to the metallurgy schedule. During the past year, he has completed all required oral and written examinations leading to a doctorate in materials science.

His doctoral thesis topic is in the field of composite materials, specifically that of understanding the effect of dispersing a hard particle within a matrix of material of lower Young's modulus and yield strength. To study this problem, which is important in WC-Co, TiC-Ni, tool bit materials, and a wide variety of other cermet materials important for their high-temperature strength and



RICHARD H. KROCK

creep resistance, he has chosen the steel-silver system as a model. Specimens have been successfully prepared by dispersing uniformly small steel ball bearings in a silver matrix. His testing program is under way.

From this investigation, Mr. Krock hopes to obtain the effect of the dispersoid size, interdispersoid thickness of matrix, and stiffness and strength of the dispersoid relative to the matrix, on such parameters as Young's modulus, initial strain hardening rate, fracture strength, yield stress variation with temperature, etc., as well as on the modes of deformation and fracture.

Mr. Krock hopes to receive his doctorate by June, 1962.

program to sponsor symposia covering state-of-the-art subjects and is endeavoring to establish a common ground among the various scientific disciplines dealing with materials, it was felt that publication of these symposia should be in a form that sets them apart from other publications of the Society. The Division has recommended to the Society that Division-sponsored symposia be published and publicized in the name of the Division and that some distinctive identification as a Materials Sciences Series be established.

Vice-Chairman Richard T. Kropf presided at the meeting for Chairman K. B. Woods, who was temporarily incapacitated.

Materials Science at Cincinnati

THE DEPARTMENT OF chemical and metallurgical engineering of the University of Cincinnati has established a new area of graduate study—materials science. Work leading to both the master of science and doctoral degrees is offered.

The university's new advanced studies are a direct outgrowth of pressing national needs for new materials of many types, according to William Licht, professor and head of the department. Cincinnati is among the first universities in the country to offer such a program. Others include Northwestern, Stanford, and Cornell. The program will be under the chairmanship of Michael Hoch, professor of metallurgical engineering. Students can enter the program from undergraduate backgrounds in either engineering or chemistry and physics.

New ARPA Contracts

THE DEPARTMENT OF DEFENSE, through its Advanced Research Projects Agency (ARPA), has awarded additional contracts amounting to \$13.4 million to universities for basic research in materials. Recipients are Brown, Harvard, M.I.T., Chicago, and Stanford. Previous contracts of this nature were awarded to Northwestern, Cornell, and the University of Pennsylvania. These recent awards are the latest in a series reflecting the present policy of the administration to strengthen basic research in specialized materials needed by newer technologies. Stringent demands on materials are resulting from the need to develop space vehicles and new weapons systems where materials are needed which are capable of withstanding extremely high temperatures and intense radiation conditions.

ACR NOTES ADMINISTRATIVE COMMITTEE ON RESEARCH

The Importance of Surfaces

By W. L. Dolch¹

THE TECHNICAL COMMITTEES of ASTM are concerned with a wide variety of materials. The research that must support our understanding, and ultimately our standards, has many common and unifying aspects. One of these should perhaps, receive more attention than it presently does.

The characteristic that I have in mind is that of interfaces or surfaces. It is hardly an exaggeration to say that the surfaces of engineering materials are their most important part. It is difficult to find a material whose uses do not depend significantly on the properties of its surfaces.

A few examples will perhaps illustrate the point. The behavior of cementitious materials like concrete is controlled by surface factors. The nucleation and growth of the new hydrated phases, the bonding of these phases into a matrix that has some stability, the bond to the aggregates, the capillary absorption of water, the nucleation and growth of ice, the progress of chemical reactions between aggregates and cement components, adsorption, capillary pressures, double layer effects and other aspects of shrinking and swelling are such examples. So are the grinding of the cement, the stabilization of entrained air bubbles in the mix, and other topics of critical importance to concrete.

Many of the above items apply also to the engineering properties of soils. Their sedimentation, consolidation, shrinking and swelling, stabilization, shear strength, and permeability are properties that are largely surface-controlled. So also is their behavior under certain climatic conditions such as freezing and the growth of ice lenses and consequent frost heaving.

Similar considerations are important to the uses of most other porous materials—building stones, insulating materials, ceramics, wood, and many others.

Metals are often thought to be examples of nonporous materials that are

not surface-dependent except for the obvious properties of corrosion and oxidation. But there are other properties that are also strongly influenced by the surfaces. The solidification of molten metals is a process that is so influenced. So also are all the properties of metals that are influenced by grain boundaries. These "surfaces" are of importance to the mechanical properties of metals, to heat treatment, and to chemical and electrochemical properties. The important considerations of friction and wear and of the lubricants that minimize them are matters of surfaces. The propagation of microcracks that results in brittle fracture and the influence of adsorbed films thereon are also surface-dependent.

Other obvious examples are the properties of surface-active materials involving all the important processes of detergency, wetting, and foaming. The stability of emulsions, the rheological and stripping characteristics of asphalts, the adhesion of paints and other coating materials, the dyeing and waterproofing of textiles, electron emissivity, and the many important aspects of heat transfer and heterogeneous catalysis are random examples of materials questions that have the properties of surfaces as controlling factors.

The above are illustrations applicable to materials under the cognizance of specific ASTM technical committees. The list could be made much longer, especially if other important aspects of surfaces, such as their influence on biological processes, were included.

It seems to me that insufficient attention is being paid to the physics and chemistry of surfaces. Papers such as that presented by Prof. M. J. Sinnott² at the 1960 Annual Meeting of the Society are all too rare. Only in comparatively recent years have adequate up-to-date general texts on surfaces, such as those by Bikerman³ and Adamson,⁴ been available. A recent review by the Division of Colloid Chemistry of the American Chemical Society⁵ of the courses in surface chemistry available in university departments in this country showed a disappointingly small importance being attributed to this question.

Perhaps ASTM members could consider ways in which these matters of surfaces, which are so important to engineering materials, can be emphasized in our educational institutions and our technical societies.

¹ Associate Professor of Civil Engineering, Purdue University, Lafayette, Ind.

² M. J. Sinnott, "The Influence of Surfaces on The Properties of Materials," *ASTM STP No. 283*, Am. Soc. Testing Mats. (1961).

³ J. J. Bikerman, "Surface Chemistry," 2nd Edition, Academic Press, Inc., New York, N.Y., 1958.

⁴ A. W. Adamson, "Physical Chemistry of Surfaces," Interscience Publishers, Inc., New York, N.Y., 1960.

⁵ K. J. Mysels, "A Survey of Course Offerings in Colloid and Surface Chemistry, 1959," *Journal of Chemical Education*, Vol. 37, p. 355 (1960).

ACTIONS ON STANDARDS

The Administrative Committee on Standards is empowered to pass on proposed new tentatives and revisions of existing tentatives, tentative revisions of standards, and the withdrawal of tentatives and standards offered between Annual Meetings of the Society. On the dates indicated, the Standards Committee took the following actions. Anyone interested in securing copies of the standards should write to Headquarters regarding their availability.

Steel (Approved July 6, 1961)

New Tentative Specification for:

General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes (A 450 - 61 T)

Revision of Tentative Specifications for:

Seamless Steel Boiler Tubes (A 83 - 60 T)
Seamless Low-Carbon and Carbon-Molybdenum Steel Still Tubes for Refinery Service (A 161 - 60 T)

Electric-Resistance-Welded Steel and Open-Hearth Iron Boiler Tubes (A 178 - 60 T)

Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes (A 179 - 60 T)

Seamless Steel Boiler Tubes for High-Pressure Service (A 192 - 60 T)

Seamless Cold-Drawn Intermediate Alloy-Steel Heat-Exchanger and Condenser Tubes (A 199 - 60 T)

Seamless Intermediate Alloy-Steel Still Tubes for Refinery Service (A 200 - 60 T)

Seamless Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes (A 209 - 60 T)

Medium-Carbon Seamless Steel Boiler and Superheater Tubes (A 210 - 60 T)
Seamless Alloy Steel Boiler, Superheater, and Heat Exchanger Tubes (A 213 - 60 T)

Electric-Resistance-Welded Steel Heat-Exchanger and Condenser Tubes (A 214 - 60 T)

Electric-Resistance-Welded Steel Boiler and Superheater Tubes for High-Pressure Service (A 226 - 60 T)

Welded Austenitic Stainless Steel Boiler, Superheater, Heat Exchanger, and Condenser Tubes (A 249 - 60 T)

Electric - Resistance - Welded Carbon - Molybdenum Alloy-Steel Boiler and Superheater Tubes (A 250 - 60 T)

Seamless and Welded Steel Tubes for Low-Temperature Service (A 334 - 60 T)

Seamless and Electric Welded Low Alloy Steel Tubes for Economizers (A 423 - 60 T)

Revision and Reversion to Tentative of Specifications for Copper Brazed Steel Tubing (A 254 - 58)

A general requirement specification for a group of steel products has proved satisfactory in the fields of structural steel, pressure vessel plate, and bar steel. In

this arrangement all of the requirements that are common to a group of specifications are included in the so-called general requirement specification. The individual product specifications then refer to the general requirement specification and include only the quality requirements necessary for the individual product covered. This arrangement has now been extended to cover carbon, ferritic alloy, and austenitic alloy steel tubes which fall under the jurisdiction of Committee A-1 on Steel. There are four specifications for corrosion-resisting ferritic and austenitic alloy steel tubes (A 268, A 269, A 270, and A 271) which are not included in this rearrangement. These fall under the jurisdiction of Committees A-1 and A-10. It is expected they will be included next year after Committee A-10 has given consideration to this proposal.

Filler Metal (Approved May 10, 1961)

Tentative Specification for Aluminum and Aluminum-Alloy Welding Rods and Bare Electrodes (B 285 - 57 T)

Revision.—A number of changes have been made to bring the specification in accordance with industry practice.

Magnetic Properties (Approved May 10, 1961)

Standard Definitions of Terms, With Symbols, Relating to Magnetic Testing (A 340 - 49)

Revision and Reversion to Tentative.—The definitions have been brought up to date with current magnetic testing practice.

Non-ferrous Metals and Alloys (Approved May 10, 1961)

Tentative Specification for Factory-Made Wrought Nickel Base Alloy Welding Fittings (B 366 - 61 T)

New Tentative.—This specification covers wrought welding fittings for pressure piping, factory-made from nickel and nickel-base alloys. The term "welding fittings" applies to butt-welding or socket-welding parts such as 45-deg and 90-deg elbows, 180-deg bends, caps, tees, reducers, lap joint stub ends, and other types as covered by the American Standard for Steel Butt-Welding Fittings B16.9-1958, the Standard Practice for Light Weight Stainless Steel Butt-Welding Fit-

tings (SP 43) of the Manufacturers' Standardization Society of the Valve and Fittings Industry, and the American Standard for Steel Socket-Welding Fittings (B16.11-1946).

Tentative Specification for Titanium and Titanium Alloy Castings (B 367 - 61 T)

New Tentative.—Three grades of castings are covered by this specification: grade C-1 for unalloyed titanium; grade C-2 for titanium alloy (6 per cent aluminum, 4 per cent vanadium); and grade C-3 for titanium alloy (5 per cent aluminum, 2.5 per cent tin).

Glass and Glass Products

(Approved May 10, 1961)

Standard Definitions of Terms Relating to Glass and Glass Products (C 162 - 56)

Tentative Revision of Standard.—Inconsistencies in certain existing definitions have been corrected and a number of new definitions have been added.

Sorptive Mineral Materials

(Approved July 6, 1961)

Tentative Methods for Sampling and Evaluation of Sorptive Mineral Products Used as Floor Absorbents (C 431 - 61 T)

New Tentative.—Procedures are provided for the sampling and evaluation of sorptive mineral products used as absorbents for oil, grease, water, and other liquids from floors. This is the first standard that has been prepared by Committee C-23 on Sorptive Mineral Materials.

Electrical Insulating Materials

(Approved May 10, 1961)

Tentative Method for Evaluation of Thermal Stability of Electrical Insulating Coated Fabrics by Curved Electrodes (D 1830 - 61 T)

New Tentative.—This method is intended for use in evaluating the relative thermal stability of flexible electrical insulating coated fabrics by determining dielectric strength after aging for predetermined times at elevated temperatures.

Tentative Method of Test for Electrical Resistance of Ceramic Materials at Elevated Temperatures (D 1829 - 61 T)

New Tentative.—Procedures are provided for testing ceramic materials at temperatures up to 500 C to supplement the General Methods of Test for Electrical Resistance of Insulating Materials (D 257).

Tentative Recommended Practice for Etching and Cleaning Thermosetting Copper-Clad Laminates for Electrical Testing (D 1825 - 61 T)

New Tentative.—For all electrical testing, but particularly for accurately measuring surface resistance or insulation resistance of etched metal clad laminates, it is most important to etch and clean the surfaces in such a manner that an accurate pattern is obtained and no contaminants remain to influence the measurements. Minor irregularities in the pattern or

traces of the etchant or other impurities in or on the surface affect the results significantly. For this reason the recommended practice was prepared.

Tentative Methods of Sampling and Testing Untreated Paper Used for Electrical Insulation (D 202 - 60 T)

Revision.—A statement of the significance of the apparent density of paper has been added to Section 11, and provisions have been made for measurements of the "wet-wet" and "wet-dry" densities of paper.

Tentative Methods of Testing Nonrigid Vinyl Chloride Polymer Tubing (D 876 - 60 T)

Revision.—The tests for dielectric breakdown and dielectric breakdown at high humidity have been revised to bring these procedures in line with current practice in the testing of nonrigid vinyl chloride polymer tubing.

Tentative Methods of Testing Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical Insulation (D 1000 - 60 T)

Revision.—The most commonly used equipment in the evaluation of insulation measures resistance rather than conductance, and therefore the indirect method for measurement of electrolytic corrosion (Sections 48 to 53) has been changed from a conductance to a resistance measurement.

Adhesives (Approved May 10, 1961)

Tentative Recommended Practice for Exposure of Adhesive Bonded Joints and Structures to the Atmosphere (D 1828 - 61 T)

New Tentative.—The use of adhesives for wood-to-wood and metal-to-metal applications subjected to long-term exposure in building constructions prompted the preparation of this recommended practice.

Peeping Fibers

FLEXIBLE BUNDLES of glass fibers are now being used to see around corners. An optical image projected onto one end of such a bundle will appear at the other end with little loss in brightness and quality. Through the use of suitable accessories, long bundles can be used as optical probes for inspection of otherwise inaccessible locations—for example, the inside of a fuel tank. Optical fiber probes are now produced commercially, and glass-fiber optics is already an important research technique.

The fibers now available are generally in the range of 0.0002 to 0.004 in. in diameter; each is of optical quality glass, coated with a thin layer of another kind of glass, having a different index of refraction. Consequently, any light entering one end of the fiber will be reflected from the inside of the coating and will be transmitted to the far end of the fiber through a series of total internal reflections.

For normal imaging purposes, bundles of several hundred thousand fibers are used; they are available up to several million fibers. The bundles are supplied in a protective cover; the range of sizes is from 1 sq mm to 1 sq in. in cross-sectional viewing area. An image is projected onto the sensing end with a lens, and each fiber senses a small part of it. At the viewing end of the probe, the image appears as a pattern of light and dark dots, like the halftone pictures in a newspaper—the greater the number of fibers, or dots, the better the image. If one of the fibers should get broken, it would show up as a black spot in the image display. In practice, the bundle can be bent to a radius of about 20 times the diameter of the individual fibers without breakage or distortion of the image.

Optical accessories may be used with optical probes for scientific purposes. In one research program, the image is fed into a television camera and projected on a wall screen. The system can be adapted to fluoroscopic examinations as well, by coating the sensing end of the probe with a suitable phosphor. A further advantage is that, if levels of illumination or X-radiation are low, the image can be intensified electronically.

When there is no light at all, an optical probe can be used both to transmit light to the area to be inspected and return the reflected light to the observer. Applications include examination of remote or dangerous locations such as the insides of atomic reactors, airplane wings, or storage tanks for fuel. An optical probe carries no electricity and would therefore prove safe in many hazardous or difficult jobs of inspection.

Industrial Bulletin No. 378
Arthur D. Little, Inc.

COMING MR&S PAPERS

Quick and False Set in Portland Cement—W. C. Hansen, consulting chemist.

The Indirect Tension Test for Concrete—N. B. Mitchell, Cornell University.

Quick-Response Thermal-Conductivity Measurements for Thermal Insulation—R. H. Norris and N. D. Fitzroy, General Electric Co.

Compatibility Between Bitumens—Exudation vs Insulation—G. L. Oliensis, Lloyd A. Fry Roofing Co.

Sinusoidal Strain Dynamic Testing of Rubber Products—A. R. Payne, Rubber and Plastics Research Association of Great Britain.

Improved Adiabatic Calorimeter for Concrete—David Pirtz, University of California.

A Technique for Observing Structure-Soil Interaction—E. T. Selig, Armour Research Foundation.

Volume Changes in Concrete—M. A. Swayze, Lone Star Cement Corp.

RANDOM SAMPLES

New Superconductor

A NEW SUPERCONDUCTOR material that offers no resistance to appreciable quantities of electrical current has been developed by Atomics International, a division of North American Aviation, Inc., under a research contract with the Atomic Energy Commission.

A wire that can be easily coiled has been drawn from the new superconductor. At liquid-helium temperatures (-452 F) the wire has conducted 100,000 amp of electrical current per sq cm in a moderately high magnetic field (30,000 gauss). This performance may be roughly equated to operation of a household electrical appliance at about 100 kw from a 110-v wall outlet.

The new material is a cold-worked alloy of approximately three parts of columbium to one part of zirconium. It is malleable and strong and can be made into wires, bars, strips, and other

shapes without losing its superconducting properties. It is expected to retain these characteristics in substantially higher magnetic fields. Its development makes possible the fabrication of superconductor magnets to replace conventional bulky and relatively inefficient iron-core electromagnets. The superconductor magnet has no iron core and may produce magnetic fields many times higher than conventional electromagnets in common application today.

Potentially, the use of superconducting magnets of 100,000-gauss strength for high-energy particle accelerators, or in connection with controlled thermonuclear research devices, could reduce their cost of operation. Superconducting magnets may also be important in space technology where lightweight magnets are needed. Such magnets could store more electrical energy in less space than conventional electrical capacitors.

LETTERS

¶ With reference to your recent question "How much do you want to know about penguins?" (*MR&S*, April), I wholeheartedly endorse the February 10 recommendation of the Administrative Committee on Papers and Publications.

I have the feeling or impression (perhaps unwarranted) that ASTM authors are particularly guilty of including too much tabular and, in some cases, graphical detail. I am certainly in favor of decreasing publication costs per page as well as favoring more readability and more concise papers.

ROBERT M. BERG,
Staff Manager,
Union Carbide Chemicals Co.,
South Charleston, W. Va.

¶ In our paper, "Compression Testing of Gypsum Plaster" (*MR&S*, May 1961, pp. 374-381) several printing errors have occurred. The most serious of these is in Table VII on page 379, where the underlining linking values not significantly different has been misplaced. The table should be as shown below.

Other errors noticed (apart from a few typographical errors where the correct reading is obvious) are:

Page 375, column 3, line 6; for "shifted" read "sifted."

Page 377, column 2, line 3; for "dry-set" read "dry set."

Page 379, Table VI; the means for plaster D have been omitted. They should be: wet, 0.39; dry, 0.39.

Page 381, Table X; for " $S_m^2 S^2$ " read " S_m^2/S^2 ."

On page 375, column 2, under "Setting Times," we stated that the advantages and precision of the method (of measuring the time of initial set) were to be discussed elsewhere. This discussion has now been published as: E. H. Waters and K. W. Lewis, "Measurement of the Time of Initial Set of Gypsum Plasters," *Chemistry and Industry*, No. 37, pp. 1156-1158, Sept. 1960.

E. H. WATERS,
R. BIRTWISTLE,
Division of Building Research,
Commonwealth Scientific and Industrial
Research Organization, Highett, Victoria,
Australia

¶ The article on ASTM Specifications in the Southern Standard Building Code appearing in the May issue of *MR&S* has been read with interest. The inset regarding building code organizations correctly indicates the desirability of communities' adopting a model building code. Unfortunately it does not refer to the National Building Code published by the National Board of Fire Underwriters, which was the first model building code prepared for adoption by communities in this country.

We would appreciate it very much if you would kindly make an appropriate announcement regarding the National Building Code in the next issue of *MR&S* in order to give appropriate recognition to the oldest of the model building codes.

E. W. FOWLER,
Chief Engineer,
The National Board of Fire Underwriters,
New York, N. Y.

[The article listed the four organizations of building officials in the United States that publish model building codes. The National Board of Fire Underwriters is a nationwide factual, engineering, and educational organization of capital stock fire insurance companies. In addition to the National Building Code, this organization publishes an electrical code and a model fire prevention code.—Ed.]

¶ This is in regard to your editorial comment in the April 1961 issue.

I have found that in trying to use data from the literature, and especially statistical data, there is seldom enough information given and it is necessary to go to the authors. Therefore I would be inclined to accept the recommendation of your Administrative Committee on Papers and Publications. I do raise the following questions, however:

1. Why except statistical studies? Data from these can generally be presented graphically or in summary-table form, and will be more meaningful to the average reader. Others will have to go to the authors or your files, anyhow, so why not for the costly tabular information too?

2. A period of five years is adequate for data which are not used as the basis for an ASTM standard. Data which are the basis for a standard should be permanently filed under the ASTM designation number and made available to the committee when revisions are contemplated.

3. A footnote to the paper should indicate that substantiating tables and details are in the Society's files, and a copy is available for loan on request.

4. There are exceptions to every rule. In certain rare instances, when authors explain why and editorial readers agree, inclusion of detailed tabular data in the published paper may be justified.

T. W. LASHOF,
Physicist,
National Bureau of Standards,
Washington, D. C.

Soviet Engineers Studied

RECENT ACHIEVEMENTS and future goals of the Soviet Union in the field of engineering and engineering education and manpower utilization are presented in a report just published by Engineers Joint Council, Inc. The U.S.S.R. annually graduates approximately 117,000 engineers, compared to 38,000 for the United States, and Soviet plans call for substantial increases in that number.

The report, "The Training, Placement and Utilization of Engineers and Technicians in the Soviet Union," is based on a tour of the Soviet Union made last year by six representatives of United States engineers sponsored by EJC with financial support of the National Science Foundation and under an exchange agreement between the U. S. and the U.S.S.R. The 112-page document is available in limited numbers for \$1.00 from Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

Soviet Advances in Metallurgy Reviewed in New Translation

THE BOARD OF GOVERNORS of *Acta Metallurgica* has announced the publication of *Contemporary Problems of Metallurgy*, edited by A. M. Samarin. It is published by Consultants Bureau Enterprises, Inc. for the Board of Governors of *Acta Metallurgica* under a grant from the National Science Foundation. The book is a translation from the Russian originally published by the Academy of Sciences USSR Press. This book was selected for translation into English because it offers Western scientists a comprehensive review of the most significant research and industrial applications in the field of metallurgy developed in the Soviet Union.

The 530-page book is priced at \$16. Members of sponsoring and cooperating societies (of which ASTM is one) may purchase the book directly from the publisher at \$12 a copy. Orders should be addressed to Consultants Bureau Enterprises, Inc., 227 W. 17th St., New York 11, N. Y., and should indicate that the individual is a member of ASTM.

TABLE VII.—EFFECT OF TIME ON WET STRENGTH OF PLASTERS, PSI.

Plaster	Testing Time, hr from casting						R ^a
	1	2	3	5	7	25	
B.....	225		540	570			526
C.....	624	742	744	744	758 ^b	714	706
D.....	218	568	570	566	564	572	562
E.....	618	619	628	622	624	634	609
F.....	416	480	485	460	481	474	446

^a Rewetted, that is, dried after 24 hr damp storage and then rewetted before testing.

^b Values underlined do not differ at the 5 per cent level of significance.

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A Glossary of Petroleum Terms, 3rd Edition

Edited by George Sell, F. Inst. Pet., The Institute of Petroleum, London, England (1961); 48 pp.; 5s.

Reviewed by R. P. Lukens, ASTM Staff.

AS NOTED IN THE Introduction, "The scope of this edition . . . has been widened to cover, as far as possible, the whole of the petroleum industry including drilling and production, processing and refining, as well as marketing and standardization."

Over 450 terms are listed alphabetically with adequate cross-referencing. Since the glossary is a British publication, some of the terms represent usage that is distinctly theirs, such as "petrol" and "motor spirit" as synonyms for "gasoline." Another difference noted is the inclusion of a definition for "petroleum ether," a term described in the ASTM Definitions of Terms Relating to Petroleum (D 288) as misleading. ASTM favors the

use of the term "ligroine," which is not listed in the IP glossary. Other terms not listed in the IP glossary but defined in Definitions D 288 include "engine distillate," "extraction naphtha," and "precipitation naphtha." In general, however, the new edition seems to be very comprehensive and should serve as a useful tool in the petroleum industry.

Bibliography of Temperature Measurement, Jan. 1953 to June 1960

By Carl Halpern and R. J. Moffat, National Bureau of Standards Monograph 27 (April 6, 1961); 13 pp.; 15 cents (Order from Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.)

Adapted from publisher's description.

MORE THAN 500 references to the field of temperature measurement are presented in this monograph, which was compiled in cooperation with the AE-2 Committee, Physical Measure-

ment Sensing, of the Society of Automotive Engineers.

Because of the favorable response to, and the continued demand for the original bibliography (1957) and its supplements, it was decided to issue the bibliography in more permanent form for wider circulation.

These references, covering the period from January 1953 to June 1960, with some earlier entries, were collected from two general sources: scientific and technical literature, and government reports.

For convenience to the user, the references are divided into a number of categories, based on the type of instrument used, including thermoelectric, resistance, radiation, expansion, aspirated, and other devices.

X-Ray Metallography

By A. Taylor; John Wiley & Sons, Inc., New York, N. Y. (1960); 993 pp.; illus.; \$27.00.

Reviewed by L. L. Wyman, National Bureau of Standards

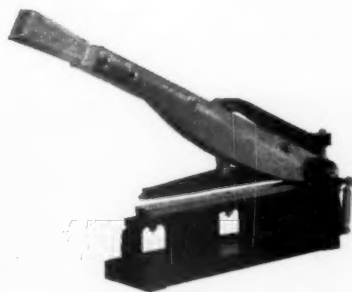
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The approach to the subject matter

(Continued on page 677)

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Calibration devices conform to the requirements of ASTM E-74 and E-83 and/or are certified by the National Bureau of Standards in cases where applicable National Bureau of Standards specifications exist.

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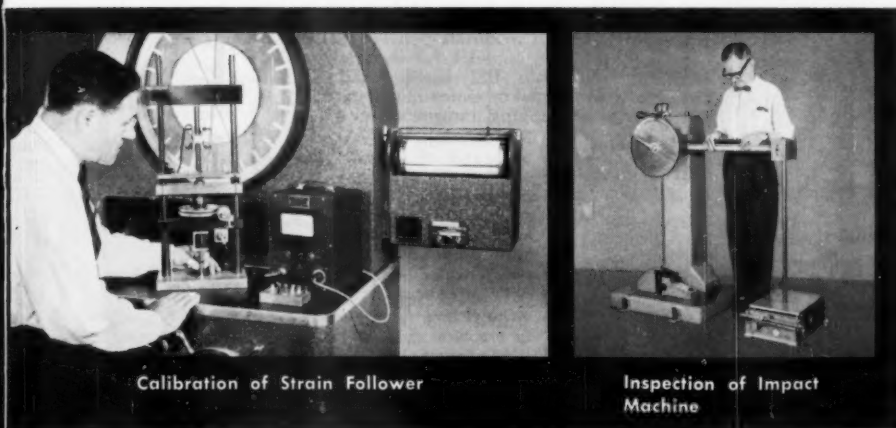


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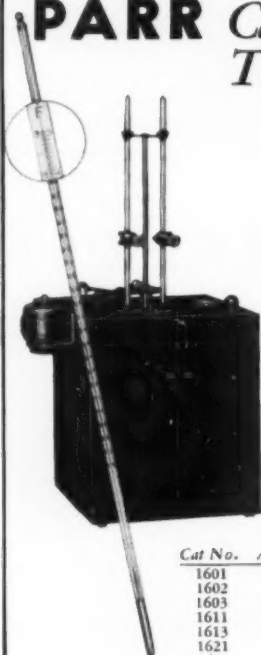
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1613	56C-59T	19- 35 C.	.02 C.
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Materials Research & Standards

BOOKSHELF

(Continued from page 673)

is that of "a physicist who learned his metallurgy somewhat later in his career," to quote the author. However, to this reviewer who made the opposite approach, the study of this excellent treatise fully reflects the fact that the author chose wisely in his manner of attacking the subject.

Following an introductory chapter in which the author very carefully describes the role of X-ray diffraction procedures as applied to metallurgy, two chapters are devoted to the generation of X-rays and their applications to radiographic procedures; this being extended through the techniques of microradiography and X-ray microscopy.

The succeeding six chapters are devoted to diffraction of X-rays, beginning with a discussion of crystals and their symmetries, the diffraction of X-rays by crystals, then progressing to the experimental techniques and equipment for obtaining diffraction patterns. The chapter on the intensities of X-ray reflections gives a particularly comprehensive explanation of factors that are frequently given too little attention by metallurgists. The last chapter in this group is devoted to an excellent discussion of the structures of the elements; this presentation including the most modern concepts of crystal structure,

thus laying groundwork for alloy considerations.

The author next turns to the application of X-ray diffraction to the more utilitarian aspects of metallographic investigation by presenting an extensive discussion of phase diagrams and the use of diffraction techniques in the study of alloy systems. This chapter is succeeded by another in which the author presents an excellent discussion of the modern concept of crystal chemistry of alloys.

The next portion of the book is devoted to the application of diffraction techniques to the study of precipitation and hardening processes in alloys; grain orientation development, evaluation, and representation; and to studies of grain size and perfection. Following these is a most factual presentation of the touchy subject of internal stresses and their measurement by diffraction techniques.

By including a chapter on chemical analysis procedures, the author develops this subject through to the latest and most powerful of metallographic tools, the electron probe. Finally, a concluding chapter on nonmetallics is most helpful to the metallurgist, for it brings in the subjects of inclusions, corrosion products, etc.

In addition to the textual portion of the book, the author has added a sizable section of tabular data to assist in the computation of lattice spacings, emission and absorption wavelengths, scattering factors, intensity corrections,

crystallographic angles, and the structure and properties of the elements. These tables are frequently needed in diffraction work, and it is most advantageous to have them available in one place.

In order to give further assistance to those interested in the practical applications of X-ray metallography, the author makes frequent reference to commercially available equipment when discussing particular techniques. To give further assistance, the author has been quite generous in his references. In fact, two chapters have 150 references, and it may be added that the book is comprehensively indexed.

This book is unusual in two respects: first, it has an astounding breadth of coverage of the entire field of fundamentals, techniques, and applications of X-ray diffraction to metallography, even expanding into electron and neutron diffraction; second, the author has displayed an unusual ability in that this highly technical subject is presented in a manner that is most readable and readily understood—it is "comfortable" reading.

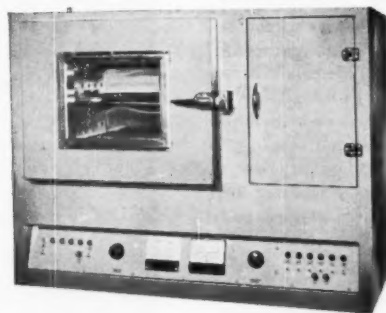
Except for the ASTM grain-size references and charts, the book has the added advantage of being really up-to-date. Although many people may consider the price of this book to be high, this volume is not merely a reference copy, but rather it is a really sound investment for the metallurgist and crystallographer, student and professional.

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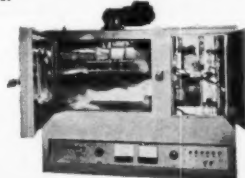
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NEW MEMBERS

The following 70 members were elected from June 8, 1961 to July 6, 1961 making the total membership 10,605 . . . Welcome to ASTM. Names are arranged alphabetically, company members first then individuals. Your ASTM Year Book shows the areas covered by the respective Districts.

Central New York District

King Laboratories, Inc., W. R. MacLeod, executive vice-president, Syracuse, N. Y.
Siver, Dougal H., manager of engineering standards, Crouse-Hinds Co., Syracuse, N. Y.

Central Plains District

Rankin, Wallace L., president, Rankin Testing Laboratory, Omaha, Nebr.

Chicago District

Waterman, Fuge and Associates, Inc., Karl W. Fuge, vice-president, Fort Atkinson, Wis.
De Vane, Charles R., Jr., manager, research and development, Clark Equipment Co., Brown Trailer Div., Michigan City, Ind.
Eickner, Herbert W., chemical engineer, U. S. Forest Products Laboratory, Madison, Wis.
Nickelsen, Hubert Olaf, research chemist, Universal Atlas Cement Div., U. S. Steel Corp., Chicago, Ill.
Olsen, Paul J., development supervisor, Culligan, Inc., Northbrook, Ill.
Peterson, R. S., chief metallurgist, Delco Radio Div., General Motors Corp., Kokomo, Ind. [A].*

Rappl, Robert J., professional engineer, Grellinger-Rose Associates, Inc., Milwaukee, Wis.
Schroeder, Arthur H., Jr., chemist, Electro-Motive Div., General Motors Corp., La Grange, Ill.

Cleveland District

Karwan, Charles W., senior chemist, Ferro Corp., Cleveland, Ohio.
Snee, Charles T., chemist, AddeX Manufacturing Co., Wickliffe, Ohio.

Detroit District

Jones, John R., Jr., group leader, Plastics Div., Allied Chemical Corp., Toledo, Ohio.
Stobbe, Robert A., head of laboratory, Kewaunee Manufacturing Co., Adrian, Mich.

Mississippi Valley District

Holt, John P., director of research and development, Valley Dolomite Corp., St. Louis, Mo.

New England District

Joy, Thomas W., vice-president, Cape Cod Ready Mix Concrete Co., Orleans, Mass.

New York District

Badia, Frank A., metallurgist, The International Nickel Co., Inc., Bayonne, N. J.

Birdsall, Henry A., materials chemist, American Telephone and Telegraph Co., New York, N. Y.
Brice, Lucien, industrial consultant, New York, N. Y.
Brock, George William, research associate, International Business Machines Corp., Yorktown Heights, N. Y.
Hamilton, William R., Jr., research engineer, Rail Joint Co., New York, N. Y.
Jenkins, Warren J., assistant manager of sales, Copper Range Co., New York, N. Y.
McCloskey, William Alexander, president, John H. Banks Laboratories, Inc., Palisades Park, N. J.
Viscio, Donald P., engineering laboratory supervisor, Heli-Coil Corp., Danbury, Conn. [A]
Wall, John P., purchasing agent, Frank Briscoe Co., Newark, N. J.
Wyckoff, H. S., product sales manager, Sperry Products Co., Division of Howe Sound Co., Danbury, Conn.

Northern Plains District

Enzmann, Ralph, research group leader, Minnesota & Ontario Paper Co., International Falls, Minn.

Northwest District

Hews, R. J., president, Yakima Cement Products Co., Yakima, Wash.
Trumbull, Robert W., president, Trum-Tube, Inc., Portland, Ore.

Ohio Valley District

Wallace, Charles Thomas, chemist and preparation engineer, Evans Elkhorn Coal Co., Inc., Wayland, Ky.

Pittsburgh District

Keane, John D., director of research, Steel Structures Painting Council, Pittsburgh, Pa.
Marshall, George W., chief inspector, Pittsburgh Steel Foundry Corp., Glassport, Pa.
Yorke, David G., technical director, Roll Manufacturers Inst., Pittsburgh, Pa.

Rocky Mountain District

Bauer, L. F., assistant to the vice-president and engineering consultant, Standard Oil Company of Texas, El Paso, Tex.

Southeast District

Perma Spray Manufacturing Co., Inc., Louis Sorosky, president, Miami, Fla.
Santee River Wool Combing, Division of Branch River Wool Combing Co., Inc., Jamestown, S. C.
Roset, Arthur Vincent, civil engineer, Federal Aviation Agency, Area Engineer Office, Atlanta, Ga. [A]

Southern California District

Garrett, Jean B., chemist, Raw Material Testing Laboratory, Hyland Laboratories, Los Angeles, Calif.
Hribar, V. F., member of the technical staff, Hughes Aircraft Co., Culver City, Calif.
McMurray, Mary R., secretary-manager, Concrete Masonry Assn., Los Angeles, Calif.
Schauwecker, Norman W., material and processes supervisor, Gilfillan Bros., Inc., Los Angeles, Calif.

Southwest District

Cummings, T. F., chemist, Southwestern Portland Cement Co., Odessa, Tex. [A]
Lunsford, Lee R., senior structures engineer, General Dynamics Corp., Fort Worth, Tex.
Shapiro, R. M., development project engineer, Schulumberger Well Surveying Corp., Houston, Tex.
Wood, Fenton M., vice-president, research and development, Tuboscope Co., Houston, Tex.

Washington, D. C. District

Hercules Powder Co., Allegany Ballistics Laboratory, Ross H. Petty, technical librarian, Cumberland, Md. [S]**
Ring, George W., III, highway research engineer, Bureau of Public Roads, Washington, D. C.

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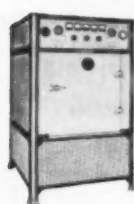
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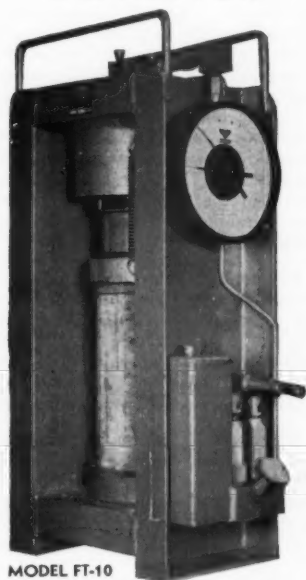
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August 1961

Western New York—Ontario District

Getters Electronics, Inc., R. G. Webster, manager, Grand Island, N. Y.
Bulger, William J., chief chemist, Varcum Chemical Div., Reichhold Chemicals, Inc., Niagara Falls, N. Y.
Campbell, George S., manager of laboratories, Atlas Steels, Ltd., Welland, Ont., Canada.
Joffe, Boris B., president, Twin City Testing Corp., Tonawanda, N. Y.
Madgett, Edward D., chief engineer, Line and Cable Accessories, Ltd., Newmarket Ont., Canada.
Sheld, Clarence A., head, Chemical Research and Development Dept., Bausch & Lomb, Inc., Rochester, N. Y.

Outside Established Districts

Leavitt, George E., assistant manager, operations, Clarke-Halawa Rock Co., Hawaiian Div., Pacific Cement and Aggregates, Inc., Honolulu, Hawaii.

Other Than U. S. Possessions

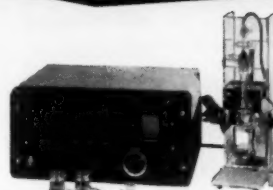
Atlantic Inspection Co., Ltd., Taipei, S. K. Chaw, general manager, Taipei, Taiwan, Republic of China.
Cementos Veracruz, S. A., Guillermo Uriarte, general superintendent, Orizaba, Veracruz, Mexico.
Comalco Products Pty., Ltd., F. F. Espie, general manager, Fairfield, N. S. W., Australia.
Breedveld, G. J. F., director and general manager, Cardon Refinery, Cia. Shell de Venezuela, Ltd., Refineria Cardon, Punto Figo, Estado Falcon, Venezuela
Calderon, Miguel M., vice-president, Laboratorios de la Ingenieria, A. C., Mexico, D. F., Mexico.
Canada Department of National Defence, Army Development Establishment, Army Headquarters, Ottawa, Ont., Canada.
Chen, Tai-Hsing, assistant engineer, China Textile Industrial Corp., Nei-li, Chung-li, Taiwan, Free China. [A]
Escuela Politecnica del Litoral, Guayaquil, Ecuador.
Fuller, R. A., director of research, Johnson & Johnson, Ltd., Montreal, P. Q., Canada.
Gomez, Anibal, professor, College of Industrial Engineers, Universidad Tecnica del Estado, Santiago, Chile.
Industry Inst., Munir D. Attiyah, director, Corniche el Manara, Beirut, Lebanon.
Natal, University of, Library, Librarian, Durban, South Africa.
Pacheco Montero, Rafael, chemist, Cementos Portland del Bajio, S. A., Leon Guanajuato, Mexico.
Robinson, Peter John Mackenzie, managing director, Foundation Engineering (Nigeria), Ltd., Lagos, Nigeria.
Wilson, J. G., chief metallurgist, Lysaght's Scunthorpe Works, Scunthorpe, Lincolnshire, England.

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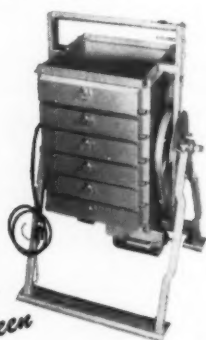
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NEWS OF MEMBERS

At the recent annual meeting of the American Society for Engineering Education, **Solomon C. Hollister**, dean emeritus, School of Engineering, Cornell University, Ithaca, N. Y., was awarded honorary membership, and **Nathan M. Newmark**, head, Department of Civil Engineering, University of Illinois, Urbana, Ill., received the Vincent Bendix Award for outstanding research contributions by an engineering educator.

The National Academy of Sciences-National Research Council has announced the appointment of **A. Allan Bates**, vice-president, Portland Cement Assn., Chicago, Ill., and **Robert F. Legget**, director, Division of Building Research, National Research Council, Ottawa, Canada, to the Special Advisory Committee of the Building Research Advisory Board for the Study of Building Research in the National Bureau of Standards. Dr. Bates recently retired as president of ASTM, and Mr. Legget is currently serving on the Board of Directors.

L. D. Andrews has recently been made the director of ferrite research, Stackpole Carbon Co., St. Marys, Pa. He had been chief engineer.

E. F. Ball, chief engineer, Bethlehem Steel Co., Bethlehem, Pa., retired June 30, 1961. Mr. Ball has been a member of the Society since 1954.

O. A. Battista has been advanced to manager, corporate applied research, American Viscose Corp., Marcus Hook, Pa. Dr. Battista is one of the inventors of Avicel, the cellulose food.

Victor W. J. Franceschini, formerly metallurgist, General Precision Laboratory, Inc., Pleasantville, N. Y., is now professor, supervisor of Metallurgy Dept., Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

John L. Hague has been appointed chief, standards reference materials, National Bureau of Standards, Washington, D. C. Mr. Hague had been acting chief, analytical chemistry.

Ralph M. Hardgrove, research consultant, Babcock & Wilcox Co., Research Laboratory, Alliance, Ohio, retired August 1, 1961. He represented his company on Committees D-5 on Coal and Coke and E-7 on Nondestructive Testing. He also represented The American Society of Mechanical Engineers on ASTM Committee D-5 and ASA Project Z23, Sectional Committee on Specifications for Sieves for Testing Purposes.

Bobby G. Johnson is now materials and process engineer, Boeing Airplane Co., Wichita, Kans. Previously he was with McDonnell Aircraft Corp., St. Louis, Mo.

William W. Karl is vice-president, Mytralite Aggregates Inc., Verona, N. J. He had been president, Lehigh Materials Co., New York, N. Y.

Robert S. Kelly, formerly chief chemist, Wilbur B. Driver Co., Newark, N. J., is now with Republic Aviation Corp., Materials Development Laboratories, Paul Moore Research and Development Center, Farmingdale, N. Y.

C. E. Laitsch, formerly metallurgist, The Grand Rapids Brass Co., Grand Rapids, Mich., is now an agent for firms whose objective is to furnish complete metal finishing equipment service.

Craig F. Leiser, formerly ceramist-metallurgist, General Electric Co., Vallecitos Atomic Laboratory, Pleasanton, Calif., is now ceramic engineer, Minnesota Mining and Manufacturing Co., St. Paul, Minn.

Brother **Amandus Leo**, F.S.C., dean, School of Engineering, Manhattan College, Bronx, N. Y., retired at the end of the 1960-1961 academic year. Brother Leo represented the college in Society membership.

Raymond C. Machler, director of research, Leeds & Northrup Co., Research and Development Center, North Wales, Pa., has been transferred to the grade of Fellow in the American Institute of Electrical Engineers "... for contributions in the field of electrical measurements."

Sherwood V. Marlowe, prior to becoming a test engineer at the Stevens Institute of Technology, Davidson Laboratory, Hoboken, N. J., served in the same capacity with Geological Survey Units, Jersey City, N. J.

Howard G. Minckler is assistant secretary, Contractors Association of Philadelphia and Eastern Pennsylvania, Philadelphia, Pa. Previously he was engineer, Alexander Construction Co., Inc., Chester, Pa.

Past-President **Norman L. Mochel**, manager, metallurgical engineering, Westinghouse Electric Corp., Philadelphia, Pa., has received from the Philadelphia Chapter of the American Society for Metals its 1961 Award as the Delaware Valley Metals Man of the Year. The citation notes that the award is in recognition of his metallurgical accomplishments, his ability as an executive of the metal industry, his many efforts in behalf of the chapter, ASM, and in the profession, and "for having characteristics ASM members prefer and admire in their executives." As chairman of ASTM Committee A-1 on Steel for many years, Mr. Mochel has a long record of accomplishments in the Society in both the ferrous and non-ferrous metals committees and administrative activities.

Peter Payson, assistant director of research, Crucible Steel Company of America, Pittsburgh, Pa., received an honorary Doctor of Engineering degree from Stevens Institute of Technology, Hoboken, N. J., for his "many achievements in the general field of metallurgy."

Materials Research & Standards

David E. Pearsall retired on July 1, 1961 as administrative director, Bickford Research Laboratories, Inc., Avon, Conn. Mr. Pearsall was a member of the Society for more than 20 years.

Jaroslav Pluhar, formerly with Vyzkumny ustav Materialu, Prague, Czechoslovakia, has been appointed a professor at the Technical University, Prague.

Harold J. Read, professor of physical metallurgy, The Pennsylvania State University, received the Charles Henry Proctor Memorial Leadership Award at the annual convention of the American Electroplaters' Society. Dr. Read earned this honor for outstanding leadership and service performed as the creator of the acclaimed "Hydrogen Embrittlement in Metal Finishing" symposium.

Robert B. Rohrer, associate research director, Armstrong Cork Co., Lancaster, Pa., retired August 1, 1961. Mr. Rohrer represented his company in the Society for many years. He was a member of the Philadelphia District Council from 1948 to 1952 and served on the Dudley Medal Award Committee from 1955 to 1958.

E. E. Scholer is now doing consulting engineering in Kirkwood, Mo. Previously he had been a highway engineer, Shell Oil Co., Inc., St. Louis, Mo.

Frank W. Sheffler is now technical superintendent, Celanese Plastics Co., Batavia, Ill. He had been staff chemical engineer, Broadway Maintenance Corp., Veon Div., Long Island City, N. Y.

James F. Shook, formerly materials engineer, Highway Research Board, AA-SHO Road Test, Ottawa, Ill., is now special project engineer, The Asphalt Inst., College Park, Md.

C. D. Williams is a consulting engineer, C. D. Williams & Associates, Augusta, Ga. He had been a partner with Patchen, Mingeldorff & Williams, Augusta, Ga.

Committee D-1 on Paint, Varnish, Lacquer and Related Products.

John D. Gaffen, general manager, Cat's Paw Rubber Co., Baltimore, Md. (recently). Mr. Gaffen joined ASTM in 1950.

C. A. Jordan, General Cable Corp., New York, N. Y. (recently). Mr. Jordan was a representative of his company on Committees D-11 on Rubber and Rubber-Like Materials from 1946 to 1953, D-20 on Plastics from 1946 to 1958, and B-1 on Wires for Electrical Conductors, which committee elected him to honorary membership in 1960.

Will G. Kelley, assistant chief electrical engineer (retired), Commonwealth Edison Co., Chicago, Ill. (June 21, 1961). Since his retirement Mr. Kelley lived in Santa Barbara, Calif. He was chairman of Subcommittee X of Committee A-5 on Corrosion of Iron and Steel.

B. L. Whittier, head, Fabric Development and Construction Dept., North Carolina State College, School of Textiles, State College Station, Raleigh, N. C. (June 20, 1961). Professor Whittier was killed in an automobile accident while motoring to his summer home. He was a long-time member of Committee D-13 on Textiles, having served on many of its subcommittees, and was chairman of the main committee from 1956 to 1960. He also represented ASTM on the Joint ASTM-AATCC Committee on Textile Test Methods.

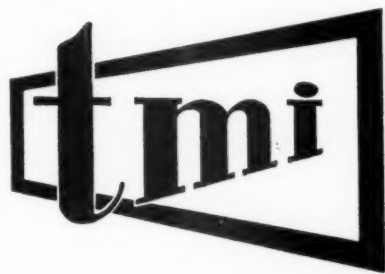
DEATHS

Harry A. Bright, retired chief, Section on Analytical Chemistry, Division of Chemistry, National Bureau of Standards, Washington, D. C. (May 22, 1961). Mr. Bright, a member of the Society since 1935, was very active in committee work over the years. He was a member of Committees E-3 on Chemical Analysis of Metals, of which committee he was honorary chairman; B-4 on Metallic Materials for Thermostats and for Electrical Resistance, Heating, and Contacts; A-9 on Ferro-Alloys; and A-3 on Cast Iron. In 1956 Mr. Bright received the Society's Award of Merit.

John M. Clemons, president, Ferro-Spec Laboratories, Inc., Los Angeles, Calif. (recently). He was a member of the Society for 10 years.

John A. Dudkoff, National Lead Co., Perth Amboy, N. J. (May 19, 1961). Mr. Dudkoff represented his company on

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VERSATILITY is another time-and money-saving feature of the Scott CRE Tester. This simple yet super-sensitive tester is designed for use with Scott's more than 150 different clamps and holding fixtures to meet ASTM, ISO and Industry Test Methods and material requirements. Moreover, Model CRE can be set up quickly for tensile, tear, adhesion, burst, seam construction and many other physical tests... with ranges from the lowest up to 1000 lbs. or 500 kgs.

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CIRCLE 1207 ON READER SERVICE CARD

682

MATERIALS AND TESTING TOPICS

This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

FOR THE LABORATORY

Insulation Testing—A new instrument for measurement of insulation resistance with d-c test potential adjustable from 0 to 2500 v, the Model 2955 Vibrotest is designed for dielectric absorption tests and plotting of insulation resistance versus time curves. The d-c test potential is continuously adjustable over the complete range allowing comparison of insulation resistance at any selected voltages.

Associated Research, Inc.

3841

Pressure Cell—A new general-purpose pressure cell, for precisely measuring fluid pressures in a wide range of applications, provides a combination of inherent high accuracy, rugged construction, long-term stability, infinite resolution, and high output signal.

Baldwin-Lima-Hamilton Corp.

3842

Macroscopic—A lightweight zoom macroscopic, ideal for quick, on-the-spot examination or measurement of objects, includes an automatic prefocus gauge, tripod leg construction for greater portability, and a special optical system which provides continuous magnification from 10 to 30X.

Bausch & Lomb, Inc.

3843

Hydrocarbon Analyzer—Two new hydrocarbon analyzers, Models 108 and 109, detect and measure trace concentrations of hydrocarbons in gases, vapors, or the atmosphere. Model 108 is for panel mounting and Model 109 is for laboratory or field use. Operating on the principle of hydrogen flame ionization of carbon atoms, the analyzer provides a sensitivity of 0 to 4 ppm carbon full-scale.

Beckman Scientific and Process Instruments Div.

3844

Test Panel—DynaPath-20 numerical control systems now incorporate a selective test maintenance panel to provide a means of isolating and testing specific logic areas and functions. This new panel contains all necessary controls for preventive-maintenance testing and is conveniently located at eye level in the rear of the control unit. Utilization of the new test panel reduces the time required for routine maintenance checks by more than 50 per cent.

The Bendix Corp.

3845

Humidity Cabinets—Foresight in design effected the uncompromising ability of this series of Blue M humidity cabinets to perform specific MIL requirements. Blue M counterflow bench-type controlled

relative humidity cabinets with saturable reactor controls are specifically designed for and guaranteed to meet MIL-202B, Method 106A, steps 1 to 6. Moreover, unit capacity is suitable to include Method 103A, procedure 2.

Blue M Electric Co.

3846

Rail Flaw Detector—A new, portable rail flaw detector incorporating several design improvements over earlier models has been announced. Completely transistorized, the Model TR-10 is much lighter, total weight is 5 lb, and much more rugged in construction. It will detect many types of incipient cracks before the rail fails entirely and causes an accident.

Branson Instruments, Inc.

3847

Strain Gage Cement—A completely new, fast-setting epoxy cement for strain gage application, called B-3, sets in only 3 hr at room temperature (setting time can be shortened to minutes by the application of heat). This fast-setting cement bridges the gap between standard epoxy cements, which take 24 hr to cure, and 1-min cements which set up so rapidly that a strain gage cannot be repositioned once it has been applied.

The Budd Co.

3848

Microscope Illuminators—The Burton line of microscope illuminators is now available for general industry. Desk, table, and laboratory models are available, as are models with optical or fresnel lenses. For use with either monocular or binocular scopes, the illuminators provide 1000 foot-candles of light at 12 in. They work on either ac or dc, any voltage, and a standard 100-w spot bulb. Fingertip adjustment governs intensity and spread. Can be used for either dark-field or light-field microscopy.

Burton Mfg. Co.

3849

Vibration Measuring System—A new vibration measuring system for use in sinusoidal laboratory vibration testing permits continuous automatic recording of complete data from accelerometer signals, including phase, distortion, and amplitude. This sampling technique is particularly useful with accelerometers, where phase and distortion information cannot be recorded by conventional techniques.

Chadwick-Helmuth Co.

3850

Low-Temperature Chamber—Designed especially for metallurgical processing of ferrous and non-ferrous aircraft-quality materials at -110 F, a new 250 cu ft chamber has been engineered for recessed installation.

Cincinnati Sub Zero Products

3851

Transducer—Two new models of the Type 4-326 strain-gage pressure transducer have been announced. One model fea-

Materials Research & Standards

tures an overpressure stop which permits two times the rated pressure to be applied for 3 min without causing a zero set to exceed 0.5 per cent of full-range output. Ten times rated pressure, or 10,000 psi, whichever is less, can be applied for 3 min without causing a zero set to exceed 1 per cent of full-range output. Pressure ranges are 0 to 100 or 0 to 5000 psi absolute and gage. The second model utilizes type 17-4 stainless steel for construction for the ease and diaphragm.

Consolidated Electrodynamics Corp. 3852

Tension Tester—A new portable tension tester of extremely lightweight design, Model VTA, is available in 50 and 100-lb capacities.

Detroit Testing Machine Co. 3853

Testers—Owners of Dillon high-capacity testers can now also test in extremely low ranges without buying a separate tester. The new Dillon interchangeable low-range head converts all high-capacity models into dual-use instruments. Interchange of the low- and high-range heads is only a matter of minutes, with ordinary tools. Both units provide a portable testing machine that can be easily moved to wherever the work is to be done.

W. C. Dillon & Co., Inc. 3854

Pyrometer—A new pyrometer offers a variety of applications for use with practically all base-metal thermocouples and can also be used as a sensitive millivolt meter for many non-pyrometric

applications. Scales are $3\frac{1}{2}$ in. long, have large, easy-to-read markings, and the three scale ranges are: 32 to 2400 F and 0 to 1370 C, for chromel-alumel (Type K) thermocouples and 0 to 50 mv (when used as a millivolt meter).

Edmund Scientific Co. 3855

Scintillation Counter—A large well counter designed to measure low amounts of radioactivity in any given sample has been designed and manufactured. Designated as Model 90-2, a sensitivity of 10^{-10} of K-40 may be detected above a background with a 20 min. count. The detector consists of a plastic scintillation well counter that measures 24 in. high, 12 in. in diameter with wall thickness of 2 in. Shielding of 5 in. of steel is provided on all sides with layered covers to facilitate removal of the subject under study.

Franklin Systems, Inc. 3856

X-ray Film—A versatile new dark-room-to-equipment-area X-ray film carrier that prevents fogged and crimped-edge films, called the Ansco-Tainer, is light-tight, lightweight, and has a durable, long-wearing, stain-resistant plastic finish.

General Aniline & Film Corp. 3857

Microscope—A new upright metallurgical microscope for vertical or inclined monocular observation can be equipped with either a plain or mechanical square stage, polarizing accessories and a wide range of coated objectives and eyepieces.

Wm. J. Hacker & Co., Inc. 3858

Current Supply—Designed to give precise, dependable voltage to meet the strict requirements of laboratory standards, an advanced d-c supply for precision potentiometers has been developed. The new unit is engineered to replace wet and dry batteries normally used to supply current to laboratory potentiometers.

Instrulab, Inc. 3859

Atomic Absorption Spectroscopy—This apparatus consists of a hollow cathode discharge tube, several burners, and a multiple pass attachment all mounted on an optical bar affixed to a high-resolution grating spectrometer. A photomultiplier mounted upon the exit slit of the spectrometer amplifies the light from the spectral line being studied. The signal is further amplified and recorded by a high-sensitivity system.

Jarrell-Ash Co. 3860

Strain Gage—An entire new line of solid-state strain gages provides higher working strain levels, increased flexibility, better handling characteristics, and smaller sizes than were previously available.

Kulite-Bytrex Corp. 3861

Laboratory Bath—The "Magnestir" baths come in four sizes, from 6 $\frac{1}{2}$ by 12 by 7 in. to 36 by 18 by 9 in. Magnetic stirring is achieved with only one moving part. This unique stirring method eliminates the need for levers, pumps,

(Continued on page 684)

Polimet

With infinitely variable speed over a wide range it is possible for the operator to select the exact speed desired for the particular sample at hand. The complete speed range is controlled by turning a knob. No cranking is required to change speed, no belts, pulleys or mechanical clutches are used, eliminating the source of most vibration present in other variable speed polishers. The electronic control is accomplished through the use of only one vacuum tube and the complete electronic circuit is mounted on a 4" x 4" panel easily accessible on the outside of the motor.

The 1851 Polimet series is furnished in the Buehler steel polishing tables, finished in silver gray hammer-tone. The top and edges of the table are black formica. One, two, or three unit tables are available.

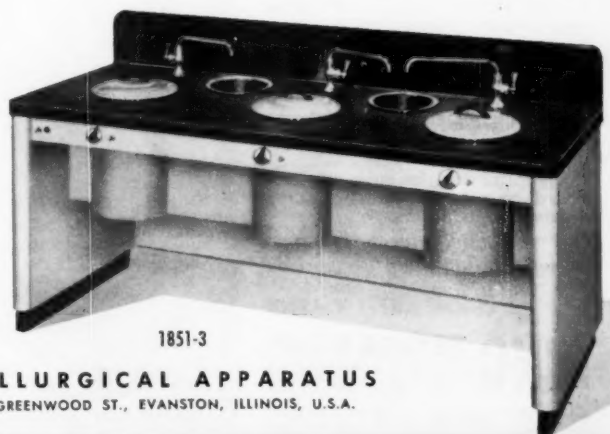


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- VIBRATION FREE
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- INTERCHANGEABLE BALANCED WHEELS
- VITREOUS FINISHED, EASY TO CLEAN BOWL



1851-3

FOR FURTHER INFORMATION CIRCLE 1208 ON READER SERVICE CARD

FOR THE LABORATORY

(Continued from page 683)

solenoids, propellers, or special linkages. The magnetic stirring bar is energized from below the chamber by a nonsparking induction motor. Uniform circulation is achieved with a flow director which surrounds the stirring bar and helps direct the water flow throughout the chamber.

Labline, Inc. 3862

Tester—A dynamic tester that uses self-correlation techniques to evaluate brush-type, V-scan shaft encoders has been introduced. Internal V-scan selection logic enables the Litton Mark I dynamic tester to compare consecutive interrogations with each other, instead of with a second "standard" encoder. Testing is accomplished under dynamic driving conditions at variable shaft speeds up to 100 rpm.

Litton Systems, Inc. 3863

Testing Machine—A new automatic hydraulic universal testing machine, designated TM-6, is designed to accommodate highly exacting test requirements for determining physical properties of all types of materials, including metals, plastics, ceramics, cermets, cloth, and paper. The TM-6 is available in 15,000, 30,000, or 60,000-lb capacity, with a hydraulic power stroke of 12 in.

The machine is automatically controlled and will test materials in tension, compression, bending, fatigue, creep, creep relaxation, and recovery.

The Marquardt Corp. 3864

Photomultiplier—Provides positioning of a photomultiplier tube on the optical axis of the exit beam and an alternate position for the photomultiplier tube at 90 deg to the exit beam. Includes sample cells of 1, 10, and 100-mm length, with lithium fluoride windows. May be used for simple detection of monochromatic radiations, or absorption, reflection, and fluorescence experiments.

McPherson Instrument Corp. 3865

Strain Indicator—A new portable transistorized strain indicator, the Model PS7-LT, operates from self-contained batteries or external a-c supply. Using integral controls it is possible to balance the measurement bridge, after which strain is read directly from the instrument. Multi-point and long-term strain measurements are also possible.

Metrix, Inc. 3866

Recording Oscillograph—A new direct-recording oscillograph with an optional built-in flash tube timer that produces full-width time lines on recording paper at any of three intervals is called the Visicorder 906C. It employs a timing circuit that can be triggered externally by either supplying pulsing voltage of 10 v at 20,000 ohms impedance, or by causing

impedance to drop to 100 ohms or less through shorting-out or other means.

Minneapolis-Honeywell Regulator Co. 3867

XY Strip-Chart Recorder—A new, movable XY strip-chart recorder quickly converts standard universal testing machines into specialized units. Plugged into any machine equipped with an adapter unit, the recorder can be used for a wide variety of functions including stress-strain curves using electronic instrumentation, stress-time studies in which the chart is driven at a fixed speed, stress-elongation tests using an electronic crosshead motion detector, or any other independent function for which provision is made.

Tinius Olsen Testing Machine Co. 3868

Electron Probe—A new, improved electron probe microanalyzer, designed for analytical determinations of elements in specimen areas less than 1 μ has been announced. Minimum amount of material the instrument can analyze is approximately 1 μ g. All elements above atomic number 11 can be identified and measured, and the limit of detectability is about 0.1 to 0.01 per cent.

Philips Electronic Instruments 3869

Portable Radioisotope Unit—A completely self-contained, portable radioisotope unit called the "Pipeliner" has been developed for versatile industrial inspection ranging from atomic submarines to welded pipelines. The Pipeliner, offering 10-, 20-, or 30-c power, can radiograph 2-in.-thick steel (it handles 1-in. steel in less than a minute). It uses iridium-192 housed in a special lead-tungsten alloy as its radiation source.

Pickering X-ray Corp. 3870

Film Applicator—A 2-path wet film applicator has a path on each side so that film thicknesses of 1 and 2 mils or 3 and 5 mils may be laid precisely. Generally used in conjunction with hiding power and penetration charts, it may also be used in the adhesive, plastics, and coatings industries for a variety of tests.

Precision Gage & Tool Co. 3871

Power Regulators—Two compact a-c power regulator systems for use where space is limited and multichannel control is needed are intended chiefly for regulation of power applied to ovens, furnaces, and similar devices in direct proportion to control signals from set point meters, temperature controllers, programmers, etc. Model Y4079 is a single-channel, plug-in module using two C16J thyristors for a rated capacity of 40 amp in each channel. Even higher capacities are available in the Model G4078 which uses ignitrons rated at 100 amp per channel.

Research, Inc. 3872

Buret—A new automatic buret with only one opening to the atmosphere (instead of two or three as in conventional designs) has been announced. According to the manufacturer, this construction permits better control of the environment above the liquid in the reservoir,

ACCURACY +



precision measurements

PORTABILITY +



Take it anywhere

ECONOMY



Cuts costs

THE KING PORTABLE BRINELL HARDNESS TESTER

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Precise quality control — the most important function of any hardness test, is one of the many reasons users depend on the King Portable! Together with the King Brinell Scope, the King Portable provides quick readings on almost any size or shape of metal in practically any location!

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reducing the possibility of contamination. It is further claimed that the unique design prohibits liquid from the preceding zeroing operation to remain in the overflow cup.

Scientific Glass Apparatus Co., Inc. 3873

Sound Meter—A new sound level meter designed to the new S1.4—1961 ASA standard is available. Called the Model 412, it operates over the exceptionally wide frequency range of 5 cps to 30 kc. A ceramic microphone allows it to be used in temperatures ranging from 0 to 170 F. There is a built-in electro-acoustic calibrator to insure consistent accurate readings at all times. The new 412 operates on two batteries plus a single bias cell. Circuitry includes seven transistors.

H. H. Scott, Inc. 3874

Elongation Tester—A special tester designated Model XE-5 is being offered specifically for determining elongation of copper wire. Model XE-5 elongation tester is used extensively by leading wire manufacturers to determine the suitability of copper conductor wire for stranding.

Scott Testers, Inc. 3875

Gyratory Testing—A new gyratory tester is a combination compaction and testing machine for use on base course materials, soils, and bituminous mixtures.

Soiltest, Inc. 3876

Power Supply—A completely transistorized Sorensen power supply, no larger than a portable phonograph and featuring an output ranging up to 36 v, is being introduced. Precise regulation of \pm (0.01 per cent plus 1 mv) and reduced ripple of 0.5 mv rms maximum results from a new circuit concept incorporated into the new Sorensen solid-state d-c power supply.

Sorensen Products 3877

Readout Instrument—A new portable bridge control readout instrument, BCR1-0, provides a combined power supply, bridge balance, and electrical readout meter for any two- or four-arm strain gage, such as pressure transducers or load cells.

Statham Instruments, Inc. 3878

Backward Wave Oscillator—A new high-performance backward wave oscillator provides between 10 and 20 mw of power throughout its range of 15,000 to 22,000 Mc. The new tube, Model OD 15-22, offers wide-range electronic tunability, a smooth curve of power output versus frequency, and highly uniform, reproducible characteristics.

Stewart Engineering Co. 3879

Power Source—A laboratory testing voltage supply transformer, known as the Lab-Pac, is designed as a means of saving time ordinarily lost with the use of makeshift arrangement. It furnishes three phases for any desired output voltage from 100 to 640 v, 30 to 60 amp ac.

The Strong Electric Corp. 3880

Vibration Meter—Meter allows simultaneous monitoring of displacement, ve-

locity, and acceleration from any piezoelectric accelerometer. It has three complete channels with meters, rack-mounted with a common power supply. A dial automatically normalizes output when set to the input accelerometer's sensitivity.

Unholtz-Dickie Corp. 3881

Environmental Chamber—The first environmental chamber with a mechanically refrigerated closed system able to reach -250 F, known as Model WT-8-250, is designed to make possible many new applications for low-temperature work in research, processing, and production.

Webber Manufacturing Co., Inc. 3882

Thermometer—A new addition to the wide-span multi-range transistorized thermistor thermometer series, the YSI Model 42SL, covers the range from -80 to 40 C in three overlapping steps. Absolute accuracy over a wide range is ± 0.5 C. Readability is 0.25 C, and reproducibility is better than readability.

Yellow Springs Instrument Co. 3883

NEW LITERATURE

Fume Hood—A new 4-page brochure describes polyethylene fume and dust scrubbers. Produced in a broad range of standard sizes, the scrubbers are designed to handle corrosive fumes and dusts with complete safety, including corrosive acids, dusts, fly ash, and harmful gases created by chemical or industrial processing operations.

American Agile Corp. 6478

SR-4 Pointer Indicator—Comprehensive information on Type 110 SR-4 pointer indicator and indicating controller is furnished in a new *Bulletin No. 4411*. The 6-page bulletin provides an extensive summary on features, applications, accuracy, and controls; a graphic selection chart; sample application system sketches; specifications table; dimensions and connection details.

Baldwin-Lima-Hamilton Corp. 6479

Viscometer—Haake rotating viscometer described in 12-page folder offers both a coaxial cylinder (cup and bob) and a plate-cone measuring system. Investigation of all manifestations of viscosity over the widest available range, 5×10^{-3} to 4×10^7 poise, is possible. It permits scientific rheological studies, rapid individual or continuous routine tests. Values are expressed directly in the international standard, centipoise.

Brinkmann Instruments, Inc. 6480

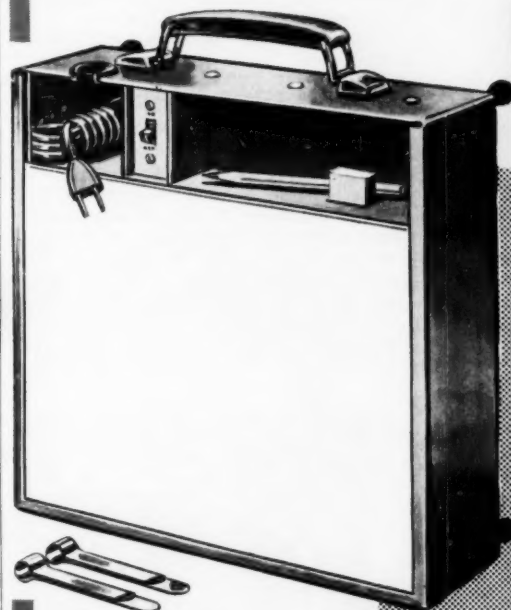
Leak Detector—Type 24-510 Radiflo leak detector is one of the most sensitive leak detection instruments ever built. Details on its efficient operation are now available in an 8-page *Bulletin 24510*. The Radiflo is capable of testing hermetically sealed components for leaks in the

(Continued on page 886)

Portable Cool...

Glow Box

THE SCIENTIST'S LIGHT BOX



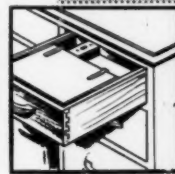
TILTS EASILY FOR TABLE-TOP USE

Model 12-12D for $8\frac{1}{2} \times 11$ " curves, charts, spectra, X-ray film, biological samples, etc.
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INSTRUMENTS for
RESEARCH and
INDUSTRY
CHELTENHAM, PA.

NEW LITERATURE

(Continued from page 685)

10⁻¹¹ atm cu cm per sec range and is noted for efficient production-line testing capabilities.

Consolidated Electrodynamics Corp. 6481

Electronic Timer—New *Bulletin 120* contains complete information on the electronic timer Model 120. It is a compact, versatile instrument that is suitable for a wide variety of industrial and laboratory uses involving automatic operation of electric circuits at pre-selected, adjustable time intervals and sequences. Bulletin includes typical applications, features, operating principle, eight circuit diagrams with complete descriptions, photographs, detailed dimension drawings, and ordering information.

Farmer Electric Products Co., Inc. 6482

Catalog—New 30-page bulletin listing optical and physical test instruments is available.

Gardner Laboratory, Inc. 6483

Air Sampling—*Dust Topics* is the title of a bimonthly magazine devoted to detailed discussions of air sampling and radioactivity measurements. New techniques and procedures are carefully examined. Current product improvements are discussed. Specifications and prices of equipment pertinent to the feature articles are presented.

Gelman Instrument Co. 6484

Strain Gages—A new 4-page catalog on 29 new Micro-Sensor® semiconductor strain gages lists the entire gage line, giving resistances, lengths, gage factors, curvature radii, temperature ranges, dimensions, and price.

Micro Systems, Inc. 6485

pH Measurement—A new *Specification S914-1* describes the integral Honeywell-Beckman system for pH measurement. The new model 75 Beckman pH amplifier is mounted in any of a variety of Honeywell ElectroniK 15 instruments for greater ease of measurement and economy of installation.

Minneapolis-Honeywell Regulator Co. 6486

Catalog—New 100-page catalog describes a full line of nuclear test equipment. Includes counters, scalars, gamma-spectrometers, detectors, and accessories.

Nuclear-Chicago Corp. 6487

Testing Machines—The complete line of two-screw and four-screw Electro-matic universal testing machines is described in 36-page *Bulletin 63* now available. Details and specifications are given on standard split cabinet electro-mechanical units in capacities to 1,000,000 lb, as well as XY units for specialized research and development testing, and a complete line of recorders, related instrumentation, and accessories.

Tinius Olsen Testing Machine Co. 6488

Laboratory Catalog—*What's New for the Laboratory*, No. 43, has just been published. This quarterly magazine serves as a supplement to SGA combined catalog 59. The new 20-page edition features many new items. Illustrated and described are the Beckman hygromite for measuring trace quantities of moisture in gases rapidly and accurately; Beckman's new line of DK spectrophotometers for analysis in the ultraviolet, visible, near-infrared and far-ultraviolet; and the new Beckman gas chromatograph temperature programmer called Thermotrac.

Scientific Glass Apparatus Co., Inc. 6489

Engineering Test Equipment—A 12-page bulletin on new products for engineering tests has been issued. Over 35 new devices for testing soils, concrete, bituminous materials, and construction materials are illustrated and described.

Soiltest, Inc. 6490

Catalog—For those interested in research, development, or quality control, a new 8-page comprehensive listing of 1239 physical testing machines for all industries obtainable from one source is now available to technical and purchasing personnel.

Testing Machines, Inc. 6491

Gradation Equipment—This booklet describes: the sieve shaker, both manual and motorized, meeting ASTM requirements; U. S. Standard sieves, 8 and 12 in. diameter; portable sieve sets; sample splitters and quartering canvas; and 15 different scales, specially selected for gradation work.

TESTlab Corp. 6492

Dosimeter—New leaflet describes the accessory equipment by which any standard Turner fluorometer is converted into a simple means of reading dosage of ionizing radiation. The introduction discusses the new line of special glasses which become fluorescent when exposed to radiation and the manner in which these materials are used to make readings from either the standard Model 110 or Model 111 Turner fluorometers—the laboratory type or the self-balancing recording type.

G. K. Turner Associates 6493

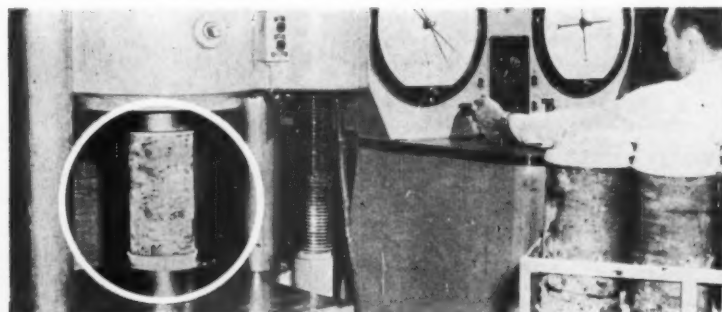
Recording Instruments—One of the most comprehensive catalogs on recording instruments has recently been compiled. Designated *No. 625*, the catalog covers all Weksler recording and controlling instruments for temperature, pressure, humidity, and time-of-operation. The catalog offers numerous aids for rapid, accurate selection of the proper instrument to meet any specific requirement.

Weksler Instruments Corp. 6494

Laboratory Catalog—The new edition of *Lablog*, supplement to Will's General Catalog 7, No. 2-61, is available. Highlighting the new issue is complete information on the Biosonik cell fracturing apparatus, which utilizes pretuned ultrasonics at 20 ke to effectively disrupt cellular material without inactivating the enzymatic protein. Sample batches from 15 to 70 ml or in continuous flow quantities may be processed. A special cooling system maintains cell slurry at a constant 5 C.

Will Corp. 6495

Materials Research & Standards



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- CYLCAP is easily poured
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Bonded Lubricant—Molykote X-15, an inorganic-bonded, dry film lubricant with a useful temperature range of from -300 to 1200 F is now being produced. In addition to its wide temperature range, Molykote X-15 is insensitive to liquid oxygen; has proved to be unaffected by up to 5×10^6 roentgen gamma radiation; retains its lubricating properties under vacuums up to 10^{-9} mm Hg; and is easy to apply in either shop or field. The lubricant has proved effective under a wide range of severe environmental conditions.

The Alpha-Molykote Corp., Stamford, Conn.

Polycarbonate Films—A 13-page technical report detailing the physical and electrical properties of LEXAN polycarbonate films is available. Designated CDC-396, this report compares extruded and solvent cast films and lists suggested applications.

General Electric Co., Pittsfield, Mass.

Ceramic Material—A new ceramic material described as combining great purity and density has been developed. The material is a translucent magnesium oxide. It comes within two per cent of "the maximum density possible," according to its developers. In addition to the greater strength possessed by the new material, its high density makes possible better finishes. When chemically polished, the magnesium oxide has a strength of 45,000 psi. Ordinary magnesium oxide has a comparable strength of 24,000 psi. The new ceramic material has an unusually high melting point, 2800 C.

Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.

Epoxy-Paper Laminate—A new grade of copper-clad epoxy-paper base laminated plastic for printed circuit manufacturing is announced. Designated Phenolite Grade EP-492-1, it offers: (1) better electrical properties than XXXP grades; and (2) improvements over standard epoxy-paper laminates in flexural strength, cold shearing, and flame resistance.

National Vulcanized Fibre Co., Wilmington Del.

Ablation Material—Taylaron 5000 is a new reinforced plastic which combines ablation resistance with thermal insulation and heat resistance and which is 25 per cent lighter in weight than equivalent materials now available. The new grade is a high-pressure reinforced plastic of alternate layers of asbestos and nylon, impregnated with a special proprietary, high-temperature phenolic resin. Prime applications are given as rocket motor liners, exhaust cones, and structural components of rockets and missiles, where the material's specific gravity of only 1.36 to 1.40 makes it especially useful in permitting substantial weight savings.

Taylor Fibre Co., Norristown, Pa.

LABORATORIES

Picker X-ray Corp., White Plains, N. Y.

—A new division to design and produce individual nondestructive testing systems for industry has been formed by Picker X-ray Corp. Nondestructive testing which has shown strong growth and a widening scope since World War II, is credited with saving industry millions of dollars annually by examining products and materials inside and out without destroying or opening them. Picker X-ray, a subsidiary of C.I.T. Financial Corp., is one of the world's largest producers of radiation and other specialized equipment for industry, medicine, and science, and produces the widest range of such equipment among U. S. manufacturers. The new division is called Picker Special Products.

Wyle Laboratories, El Segundo, Calif.

Wyle Laboratories' Parameters Division, Westbury, N. Y., has acquired a new, advanced vibration system which reportedly meets the test requirements of the latest and most powerful missiles, such as Titan II. The system includes a 50-kw Ling amplifier, Model PP 50/70, a Ling Model ESD-20/ASD-20 spectral density equalizer/analyzer which permits continuous and parallel observation and control of spectrum in random vibration test programs, and a Ling A246 vibration exciter shaker rated at 7500 lb force.

CALENDAR

Aug. 28-30—Applied Mechanics Div., American Society of Mechanical Engineers, and Engineering Mechanics Div., American Society of Civil Engineers, 1961 West Coast Conference of Applied Mechanics, University of Washington, Seattle, Wash.

Aug. 30-Sept. 1—American Institute of Mining, Metallurgical & Petroleum Engineers, Conference on Metallurgy of Semiconductor Material, Ambassador Hotel, Los Angeles, Calif.

Sept. 3-8—American Chemical Society, 140th National Meeting, Chicago, Ill.

Sept. 11-15—Instrument Society of America, 16th Annual Meeting, Instrument-Automation Conference and Exhibit, Biltmore Hotel and Memorial Sports Arena, Los Angeles, Calif.

Sept. 18-20—Standards Engineers Society, Tenth Annual Meeting, Hotel Sherman Chicago, Ill.

Sept. 24-26—Petroleum Div., American Society of Mechanical Engineers, 16th Annual Petroleum Mechanical Engineering Conference, Muehlebach Hotel, Kansas City, Mo.

Sept. 24-27—American Public Works Association, Public Works Congress and Equipment Show, Hotel Leamington and Auditorium, Minneapolis, Minn.

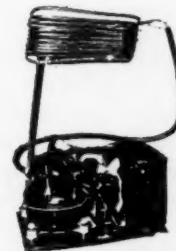
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CALENDAR

(Continued from page 687)

- Sept. 25-26—Steel Founders' Society of America, The Homestead, Hot Springs, Va.
- Sept. 25-28—American Welding Society, National Fall Meeting, Hotel Adolphus, Dallas, Tex.
- Sept. 25-28—Association of Iron and Steel Engineers, Convention, Penn-Sheraton Hotel, Pittsburgh, Pa.
- Sept. 27-29—American Association of Textile Chemists and Colorists, Annual Convention, Statler-Hilton Hotel, Buffalo, N. Y.
- Oct. 1-4—American Gas Association, Annual Convention, Dallas, Tex.
- Oct. 1-5—The Electrochemical Society, Fall Meeting, Statler-Hilton Hotel, Detroit, Mich.
- Oct. 2-3—Engineers' Council for Professional Development, 29th Annual Meeting, Sheraton Seelbach Hotel, Louisville, Ky.
- Oct. 2-7—American Rocket Society, 12th International Astronautical Congress, Washington, D. C.
- Oct. 3-5—Argonne National Laboratory, Symposium on Physics and Nondestructive Testing, Argonne, Ill.
- Oct. 8-11—National Institute of Governmental Purchasing, 16th Annual Conference and Products Exhibit, Hotel Commodore, New York, N. Y.
- Oct. 8-11—Society of Petroleum Engineers of American Institute of Mining, Metallurgical and Petroleum Engineers, Annual Fall Meeting, Memorial Auditorium, Dallas, Tex.
- Oct. 9-13—American Association of State Highway Officials, Annual Meeting, Statler-Hilton Hotel, Denver, Colo.
- Oct. 10-14—American Council of Independent Laboratories, Annual Meeting, Sheraton Hotel, Philadelphia, Pa.
- Oct. 15-19—Prestressed Concrete Institute, Annual Meeting, Brown Palace Hotel, Denver, Colo.
- Oct. 15-20—American Institute of Electrical Engineers, Fall General Meeting, Statler-Hilton Hotel, Detroit, Mich.
- Oct. 16-20—American Society of Civil Engineers, Annual Convention, Hotel Statler, New York, N. Y.
- Oct. 19-21—National Society of Professional Engineers, Fall Meeting, Roanoke Hotel, Roanoke, Va.
- Oct. 23-26—The Metallurgical Society of American Institute of Mining, Metallurgical and Petroleum Engineers, Fall Meeting, Pick-Fort Shelby Hotel, Detroit, Mich.
- Oct. 23-27—American Society for Metals National Metal Congress and Exposition, Cobo Hall, Detroit, Mich.
- Oct. 30—Nov. 1—American Oil Chemists' Society, Fall Meeting, Pick-Congress Hotel, Chicago, Ill.
- Oct. 31—Nov. 4—Federation of Societies for Paint Technology, 39th Annual Meeting and Paint Industries' Show, Shoreham Hotel, Washington, D. C.

OTS REPORTS

These reports, recently made available to the public, can be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Order by number.

Metals

- Gas Atmosphere Effects on Materials (Water Saturated Gas Atmosphere on Iron, Nickel, and Cobalt Base Materials), PB 171 980, \$3.50.
- Study of the Rate Controlling Process for Compressive Deformation of High-Purity Aluminum, PB 171 488, 75 cents.
- Study of the Alloys of Transition Elements, PB 171 113, 50 cents.
- Electron Induced Radiation Damage in Pure Metals, PB 171 523, \$1.25.
- Effect of Single Trace Alloy Additions on the Properties of Pure Iron, PB 171 045, \$2.
- Investigation to Develop Optimum Properties in Forged Ti-7Al-4Mo, PB 171 546, \$2.75.
- Corrosion Survey of Steel Sheet Piling, PB 171 501, \$1.75.
- Mechanism of Growth and Physical Properties of Refractory Oxide Fibers, PB 171 520, \$1.50.
- Preliminary Design Information on Recrystallized Mo-0.5Ti Alloy for Aircraft and Missiles, PB 161 229, 50 cents.
- Refractory Metals in Europe, PB 161 233, 50 cents.
- Physical and Mechanical Properties of Some High-Strength Fine Wires (high-carbon steels, stainless steels, nickel-base alloys, tungsten, and molybdenum), PB 161 230, 50 cents.
- Beryllium Joining, WADC-Sponsored Program, PB 161 831, \$2.75.
- Beryllium Joining, Rad-Sponsored Program, PB 161 830, \$1.25.
- Beryllium Research and Development in the Area of Composite Materials, PB 171 083, \$2.75.
- Beryllium Crack Propagation and Effects of Surface Conditions, PB 171 088, \$3.
- Beryllium: Survey of the Literature, PB 161 812, \$1.50.
- Beryllium: A Search of the Literature, 1957-1959, PB 161 811, \$2.50.
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- Evaluation of Numerically Controlled Machining of Forging Dies, PB 171 378, \$2.
- Adhesive Bonding of Metals for Advanced Ordnance Applications, PB 161 883, 75 cents.
- The Evolution of Nickel-Base Precipitation-Hardening Superalloys, PB 161 234, 50 cents.
- Review of Developments in Iron-Aluminum-Base Alloys, PB 161 232, 50 cents.

(Continued on next page)

Materials Research & Standards

Pickling and Descaling of High-Strength, High-Temperature Metals and Alloys, *PB 161 255*, 50 cents.

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Theoretical and Practical Aspects of Vacuum Induction Melting of High-Strength Steels, *PB 161 928*, \$2.

Physical and Mechanical Properties of Commercial Molybdenum-Base Alloys, *PB 151 099*, \$3.

Physical and Mechanical Properties of Tungsten and Tungsten-Base Alloys, *PB 151 084*, \$1.75.

High-Impact Metal Forming, an Annotated Bibliography, *PB 171 379*, \$1.

Heat Sinks; Materials, *PB 171 372*, \$1.

Melting and Casting of the Refractory Metals Molybdenum, Columbium, Tantalum, and Tungsten, *PB 151 098*, \$1.

Statistical Analysis of Tensile Properties of Heat-Treated Ti-4Al-3Mo-IV Sheet, *PB 151 095*, \$1.25.

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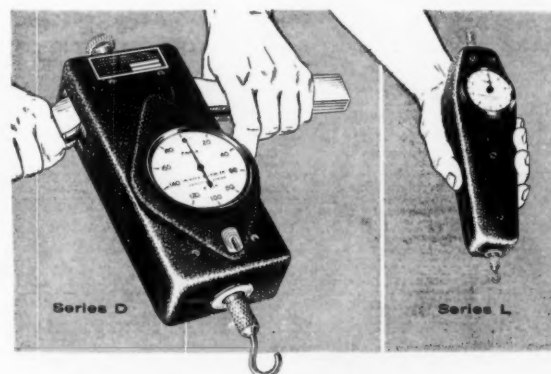
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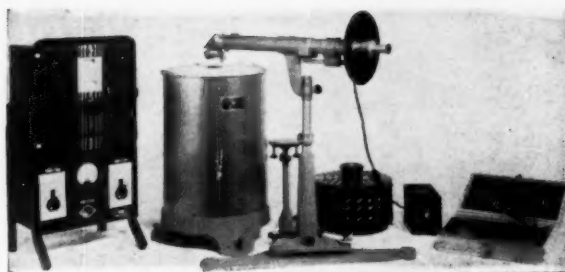
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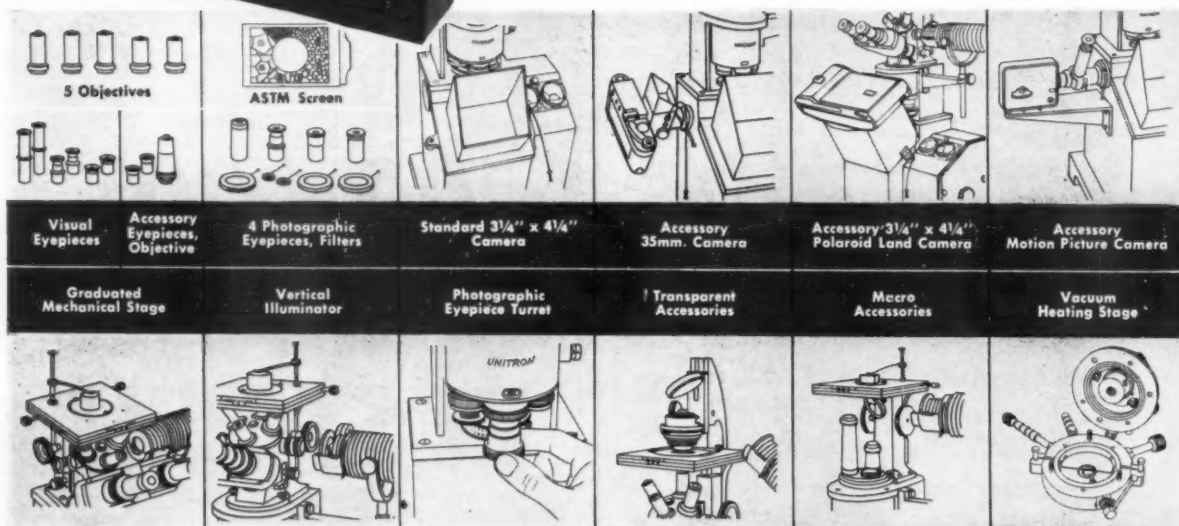
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mh

General Radio offers a wide line of fixed and variable standard inductors. Toroidal air-cored inductors, such as the Type 1482 Standard Inductor, approach the ideal; stability is high, effects of external magnetic fields are negligible, temperature coefficient is low, and inductance changes with current are minimized.

Greater economy in coil construction can be obtained using "iron" (special ferromagnetic alloys) as the core material. Although there is some sacrifice in stability, properly designed iron-cored inductors exhibit a higher Q than air-cored types, and are excellent secondary standards.



Type 1482
Standard Inductors
17 models
from 50 μ h to 10 h in 1-2-5 sequence.

Primary standard for measurements at low audio frequencies featuring high stability, high adjustment accuracy, and high certification accuracy. Uniformly wound toroid on ceramic core — negligible external magnetic field and practically no pickup. Thermal aging equalizes winding strains. May be used for either two- or three-terminal measurements — 50- μ h, 100- μ h, and 200- μ h values have six terminals for minimizing connection errors. Low temperature coefficient of 30 ppm/°C. Adjustment accuracy is $\pm 0.1\%$ for values between 500 μ h to 10 h; $\pm 0.25\%$ for 100 μ h and 200 μ h; and $\pm 0.5\%$ for 50 μ h. Typical certification of actual value given to better than $\pm (0.025\% + 0.1 \mu$ h) — long-term stability better than 0.01% per year. Prices from \$110 to \$225.

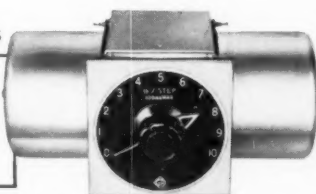


Type 1481 Inductors
16 models
from 100 μ h to 10 h
in 1-2-5 sequence.

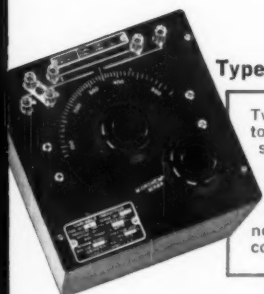
Extremely useful secondary standards for two-terminal measurements — toroidal winding on molybdenum-permalloy dust core; higher low-frequency Q values than 1482 models... electrostatically shielded. Adjustment accuracy is $\pm 0.4\%$ for 100-mh through 10-h values; $\pm 0.6\%$ for 10-mh through 50-mh values; $\pm 1.0\%$ for 500- μ h through 5-mh values; and $\pm 2.0\%$ for 100 and 200- μ h values. Stability better than 0.25% per year. Prices from \$37.50 to \$50.00.

Type 940 Decade-Inductor Units

Assemblies of four Type 1481 Inductors which are combined by switching to give eleven successive values from 0 to 10. High Q values for all models. Wax impregnation keeps out moisture — aluminum covers provide electrostatic shielding.



Type	Range	Accuracy	Price
940-DD	1 mh, total, in 100- μ h Steps	$\pm 2\%$	\$110
940-E	0.01 h, total, in 1-mh Steps	$\pm 2\%$	\$110
940-F	0.1 h, total, in 0.01-h Steps	$\pm 1\%$	\$110
940-G	1 h, total, in 0.1-h Steps	$\pm 0.5\%$	\$110
940-H	10 h, total, in 1-h Steps	$\pm 0.25\%$	\$120



Type 107 Variable Inductors

Two concentrically-mounted coils are used as stator and rotor to provide continuous adjustment of self and mutual inductance. May be connected in series or parallel. Basic calibration accuracy is $\pm 1.0\%$ of full scale. Five models available with following series-connected values: 9-50 μ h; 90-500 μ h; 0.9-5 mh; 9-50 mh; 90-500 mh. When connected in parallel, inductance is $\frac{1}{4}$ of series-connected values. Prices range from \$95 to \$110.

Type 1490 Decade Inductors

Assemblies of Type 940 Decade-Inductor Units in shielded metal cases — for 2- or 3-terminal measurements.



Type	Range	Price
1490-C	1.11 h, total, in 1-mh Steps	\$360
1490-D	11.11 h, total, in 1-mh Steps	\$460
1490-F	1.111 h, total, in 100- μ h Steps	\$450

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Standards. The proving rings shown are a good example. An electrically-vibrated reed with each ring, an Olsen exclusive, gives the most foolproof type of calibration data. The reed's distinctive "hum" tells precisely when each load value is reached. There's no margin for error here.

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